CANADA

DEPARTMENT OF MINES

HON. P. E. BLONDIN, MINISTER; R. G. McCONNELL, DEPUTY MINISTER

MINES BRANCH

EUGENE HAANEL, PH.D., DIRECTOR.

REPORT

ON THE

Production of Spelter in Canada

1916

BY

Alfred W. G. Wilson, Ph.D.

OTTAWA
GOVERNMENT PRINTING BUREAU
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LETTER OF TRANSMITTAL.

Dr. Eugene Haanel,
Director Mines Branch,
Department of Mines, Ottawa, Ont.

Sir,—

I beg to submit, herewith, a brief report on the production of Spelter in Canada. This report contains the results of an investigation into the costs of the various raw materials required by the zinc smelting industry made during the months of May, June, and July, 1916, and supplies estimates as to the probable cost of these materials at certain points in Canada. The conditions under which Canadian zinc ores are now sold to a foreign market are discussed, and the terms of a number of contracts for these and similar ores are stated. The report is concluded with a statement of the author's personal opinions in regard to certain matters in connexion with the home treatment of British Columbia zinc ores.

I was assisted by Mr. Arthur Buisson, Assistant Engineer, Division of Mineral Resources and Statistics, in the field work and in compiling some of the information used in preparing this report. The chapter on the production of zinc in Canada, which is reproduced here, was prepared by Mr. Buisson for the annual report of his division, under the direction of Mr. John McLeish, Chief Statistician.

I have the honour to be,
Sir,
Your most obedient servant,

(*Signed*) **Alfred W. G. Wilson.**

Metalliferous Division,
Mines Branch, Ottawa.
August 15, 1916.

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PRODUCTION OF SPELTER IN CANADA.

INTRODUCTORY.

The future of the zinc industry of Canada, and especially of British Columbia, is a matter of concern not only to the owners of producing properties, but also to consumers of zinc products and others who are interested directly or indirectly in our production of metals. The changed conditions brought about by the war have had a notable effect on the zinc industry in America, on which the Canadian industry is wholly dependent. It is to be anticipated that the still greater changes that may follow the establishment of closer relations between the different parts of the Empire will also have their effect on our metal production, and will be reflected in the policy adopted by our government with respect to the mining and smelting industries in general.

The production of zinc ore in Canada has never been very large, and all ores produced are exported for treatment. On the other hand, all zinc and zinc products required for home consumption have been imported. During the last three or four years our imports have exceeded our exports by almost double the amount of zinc in the ores produced in Canada. Ten years ago this condition was reversed, and we were producing more zinc than we required. It is to be noted, however, that the bulk of the zinc ores are produced in British Columbia, while the greater portion of the zinc used in Canada is required by the eastern Provinces.

In the year 1905 a special commission was appointed to investigate the conditions of the zinc industry in British Columbia. The findings of this commission were published by the Mines Branch in 1906.[1] This report includes descriptions of the principal mines and prospects known at that time, makes estimates of the prospective output of zinc ores, and enters into a full discussion of the posssibility of smelting zinc ores in British Columbia by established processes. The conclusion reached appears to have been generally overlooked. This conclusion was as follows[2]:—

It will appear therefore that smelting in Canada is feasible commercially, especially since a part of the spelter produced in Canada can be marketed domestically, saving something in freight and gaining in price. It is possible also for a Canadian smelter to compete successfully with the American so long as the United States assesses a duty of 20 per cent *ad valorem* on blende. It is to be remarked, however, that this conclusion is based on a plant of high efficiency, in thorough running order (manned competently), and on an estimate for labour that is doubtful. Until the last point has been settled, I should leave considerable leeway to cover unfavourable contingencies, and to anyone contemplating zinc smelting in the Canadian west I would emphasize again the necessity for being content with disappointing results for a considerable period while a sufficiently skilful working force is being secured.

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[1] Report of the Commission appointed to Investigate the Zinc Resources of British Columbia and the conditions affecting their exploitation. Mines Branch, Ottawa, 1906.
[2] W. R. Ingalls, in Zinc Commission Report, p. 55.

Zinc smelting, however, has not been established in Canada, even ten years after the report of the commission, the principal apparent reason being that a supply of ores, suitable for treatment by the retort process, has not been available.

The changed conditions brought about by the war make it desirable to ascertain how far the new conditions will affect our various metal industries. This report presents, in brief form, the results of an investigation into the present costs of the various raw materials required in the zinc smelting industry. An attempt has also been made to estimate the probable production of zinc ores from British Columbia mines, on the assumption that a home market for these ores could be established. This estimate is based solely on statements furnished by all the principal producers in that Province.

The information on which this report is based was obtained during a personal visit to the principal smelting centres of the United States, and to the principal zinc mines of British Columbia during the months of June and July, 1916. Additional data have also been obtained by correspondence. The writer is greatly indebted to a number of the principal zinc smelter operators in the United States for the very courteous reception he received at their hands, and for the freedom with which they supplied him with such information as he desired.

The following are the principal subjects considered in this report:—

Present cost of the various raw materials at various zinc smelting centres in the United States.

Comparative costs of these various raw materials at representative points in Canada.

Prospective output of British Columbia zinc mines.

Tariff conditions.

Electrolytic zinc in Canada.

Freight rates on various raw materials.

Ore sales and contracts.

SMELTING COSTS IN THE UNITED STATES.

The last two years have seen very marked increases in the cost of zinc smelting in the United States. Structural materials and machinery have advanced in price with attendant higher costs for construction and equipment, both at the smelters and at the mines. Wage scales have been advanced in nearly every line of industry, affecting the cost of raw materials of all kinds, including ores, coal, clays, bricks, and fire bricks, and other supplies required by the smelter. The high price of zinc has made it profitable to use more of the lower grade zinc ores than formerly; roasting and retorting have in many instances been less carefully controlled than formerly, and the plants have been operated to capacity. As a result of this pressure

the percentage recoveries have fallen considerably, and the cost per pound of zinc produced has materially increased.

Construction costs.

In 1906 Mr. W. R. Ingalls[1] gave sixteen dollars per ton of annual capacity as a fair figure on which to base an estimate of the cost of a thoroughly modern smelting plant of a capacity around 25,000 tons per annum, not, however, including an acid plant. The corresponding plant using natural gas was stated to cost ten dollars per ton of annual capacity.

One large operator recently informed me that a modern plant, over whose erection he had had supervision just prior to the war, cost $30 per annual ton of smelting capacity. This plant was equipped with roasters, producers, and an acid plant using the chamber system. All buildings were of brick and steel construction. About one half the cost of erection is charged against the acid plant. The demand for iron and steel and higher wage scales have raised the cost of structural steel and sheet steel, and long delays in deliveries are common. Increased wages in the clay industries, and a broader market have also advanced the cost of fire brick. As a consequence, the same plant, at present prices, would cost about $50 per annual ton capacity, an increase of about 66 per cent. The greater portion of this increased cost of construction should be charged against the acid plant. The increase in the cost of constructing the zinc smelter alone would probably be about 20%.

Another operator of wide experience advises me, in a personal letter, that the cost of a modern coal plant would range from $16.00 to $20.00 per annual ton, depending on the permanency of construction. This figure does not include the roasting plant and the acid plant, which would probably double the above costs. Plants using natural gas in the Oklahoma field are placed by this same operator at about $7.00 per annual ton capacity. Another authority quotes $9 to $10 per annual ton of ore capacity.

Fuel costs.

The zinc smelting plants in the United States employ a variety of fuels. To supply the heat necessary for the smelting operations the fuels used are soft coals or natural gas. Where soft coal is used the modern practice is to employ producers and to burn the resultant producer gas in the reto furnace. The heat value of this gas generally varies between 120 and 13 B.Th.U. per 1,000 cubic feet. The minimum price for coal noted by the writer was 82·5 cents per ton for Illinois soft coal screenings, f.o.b. cars at the mine. This fuel contains 12–20 per cent ash and the moisture varies from 7% to 20%. The cost at the smelters would vary from $1.00

[1] Zinc Commission Report, p. 31.

to $1.80 per ton according to location. At one plant visited, Illinois screenings were quoted at $1.65 per ton delivered. About two tons of this fuel are required per ton of ore treated. Illinois lump coal, 6" and over, is quoted at about $1.10 f.o.b. cars at the mine.

Arkansas coal is also used at some plants. This coal formerly cost $1.25 per ton f.o.b. cars at the mine, but is now quoted at $2.00. The freight rate to Bartlesville is $1.35 per ton from the Fort Smith field, and $1.45 per ton from the Spadra field.

The following table shows some recent quotations on certain soft coals in the states of Kansas and Oklahoma that are suitable for industrial purposes:—

	Mineral, Kansas.	McAlester, Wilburton, Okla.	Coalgate, Lehigh, Okla.
Mine Run..........	$1.75 to $2.00	$2.25 to $2.50	$2.10 to $2.25
Lump.............	2.00 to 2.50	3.50 to 4.00	3.00 to 3.50
Slack..............	1.25 to 1.50	1.15 to 1.35	.75 to 1.50

The cost of natural gas varies greatly according to locality. Some Kansas plants are reported to be paying as high as 15 cents per thousand. In the Bartlesville district prices were quoted as ranging from 2 to 8 cents per thousand; one large plant secures most of its supply at 3 cents. In the Oklahoma field one large plant is paying 8 cents per thousand. At Tulsa, Oklahoma, natural gas for domestic use costs 20 cents per thousand with a discount of 20% for prompt payment, the net cost to the consumer being therefore 16 cents. For industrial purposes, the prices quoted range from 3 cents to 7 cents per thousand, varying with the daily consumption. The lower rates are stated not to be available for the zinc smelter. A large supply of gas, quoted at 4 cents per thousand, is now available in certain Oklahoma fields.

Reducing materials.

Illinois smelters use *anthracite screenings* almost exclusively as a reducing material. These screenings are obtained from the docks in Chicago and Milwaukee. Prior to the war there was an abundant supply of this material available and it was obtainable at 50 to 75 cents per ton. The industrial demand created by the war has enabled the sellers to advance the price to a minimum of $1.50 per ton, and it has been sold as high as $2.50 per ton. To this must be added the cost of shipment to the smelter. The freight rate to Depue, Illinois, for example, is 70 cents per ton. About 900 to 1,000 pounds of anthracite screenings are required for each ton of green ore treated.

Coke breeze secured from the coking plants at the various steel works is another reducing material that is in good demand. The prices quoted

on this fuel ranged from $1.50 to $3.50 per ton f.o.b. cars prior to the war. The cost of this fuel at the smelters varies greatly, depending upon the distance from the point of origin. At one plant coke breeze purchased in Milwaukee at $2.25 per ton cost $3.75 per ton laid down. Another operator informed me that some coke breeze used by him had cost $5.00 per ton.

Kansas dead coal is utilized at some smelters as a reducing agent, usually being mixed with coke breeze. This material is the weathered coal that occurs near the surface, along the outcrop of coal seams and, naturally, it contains a good deal of moisture. It was quoted at $1.75 per ton f.o.b. cars at the mine, but the present price is $2.50 per ton.

Retort clays.

The principal clay used for manufacturing retorts comes from the Cheltenham district near St. Louis, Missouri. The standard price for the raw clays has been $1.50 per ton f.o.b. cars at shipping point. This price has recently been advanced to $2.00 per ton for new contracts and renewals. Dobies made locally from this clay were formerly quoted at $4.50 per ton, and this price has been advanced to $6.00. Fire bricks that formerly cost $15.00 per thousand are now quoted at $20.00.

One firm is now manufacturing a tempered clay especially prepared for making retorts. They claim that the zinc smelter purchasing this product will be assured of a uniform mixture, properly prepared under the direction of experts. This tempered clay is shipped in blocks 7·5″× 9″ × 9″, and is quoted at $10.00 per ton f.o.b. cars St. Louis. It can also be supplied re-ground and sacked at a slight advance on the above charge.

Labour costs.

The Zinc Commission report of 1906[1] states that wages range from 15 cents per hour to 25 cents per hour ($1.50 to $3 per day) at United States smelters. Assuming that the average wage per day was $2.00, and that the labour of 2¼ to 2⅜ men for one day was required to smelt one ton of zinc ore, the average labour cost of smelting was placed at $4.50 to $4.75 per ton. Since the commencement of the war, the cost of labour in the zinc smelters has very materially increased, partly on account of higher wages, and partly because of lowered efficiency, due to the introduction of untrained men. The lowest labour rate noted by the writer was $1.75 per day of 10 hours. At one plant visited, ordinary labour is paid 25 cents per hour, while the furnace labour at this plant receives $2.76 per day. Another plant in a natural gas area pays a minimum wage of $2.75 per day, and $3.41 per day to furnace labour. At this plant the head roaster man receives $4.07 per day of 12 hours, and the second man $3.41; the firemen are paid $5.72 and $4.72 respectively, while before the advance in wages they received $4.15 and $3.15 respectively.

[1] Page 54.

One large operator stated that the average wage paid in 1916 was about $3.70 per man per day, against $2.40 per day in the same plants in 1914. The average increase in labour costs, based on a study of the pay rolls of a number of plants was stated to be at least 35%. Assuming this percentage increase, the labour cost of smelting should now be placed at $6.08 and $6.41 per ton. This increase, however, does not take into account the lower efficiency of the labour employed.

Recoveries.

It is only under exceptional circumstances that recoveries of 90% have been obtained. Ingalls[1] placed the average recoveries at about 88%, when working on a good grade of ore, and stated that in some cases they fell as low as 72%. It is difficult to obtain accurate figures from individual operators, but there is no doubt that, during the last year or more, the demand for spelter has made it desirable to operate the smelters to full capacity and has lowered the percentage recoveries. A recent article in the "Engineering and Mining Journal of New York" discusses this question and states that there is talk of zinc extraction as low as 65% to 75%.[2] This article concludes with the statement that scarcity of labour is preventing the utilization of the increased capacity in the United States for spelter production, and the yield of spelter per retort in use is much below normal.

LOCATION OF A ZINC SMELTER IN WESTERN CANADA.

The two principal items of expense in the operation of a zinc smelter are the fuel supply and the labour supply. In Europe, prior to the war, the largest single item in the cost of smelting was the cost of coal; in the United States the largest single item was the cost of labour. At the present time, although there have been increases in the cost of coal, by far the greater proportional increases have taken place in the labour costs. In Canada, were a zinc smelter started here, the labour charge would also prove to be the largest single item of the cost of smelting. Since labour is mobile and, within certain limits, can be easily conveyed to the point at which it is needed, the principal factor in determining the best location for a zinc smelter is the availability of a cheap supply of suitable fuel. It is also, of course, desirable that labour and all other supplies required can be obtained at reasonable rates—transportation charges on ores supplies inward, and on output outward to market, should not be excessive, and facilities for re-shipping valuable residues to a silver-lead smelter for treatment should be available, and living conditions for the labour employed should be desirable.

[1] Zinc Commission Report, p. 32.
[2] Engineering and Mining Journal, May 6, 1916, p. 828.

Since there are no established zinc smelting centres in western Canada it becomes necessary to consider what locations, which satisfy the above conditions, are available, and what are the advantages and disadvantages of each with respect to the raw materials required by the industry. The principal controlling factors are shipping and receiving facilities, ore supply, fuel supply, labour supply, retort clay and fire brick supply. Certain localities offer advantages in one or more directions, but at the same time are distinctly disadvantageous in others, and it will only be by careful comparative studies of costs that the most advantageous location can be ascertained. The principal localities to be considered are as follows:—

Vancouver Island. Several points on the east side of Vancouver island offer excellent harbour facilities on tide water and are convenient to the Vancouver Island coal fields. These points are located about 600 miles from the principal producing zinc mines of the Kootenays. On the other hand they are advantageously located to import zinc concentrates from Australia should the British Columbia supply prove inadequate. Nothing is known about the suitability of local fire clays, and such materials and their products would have to be imported either from the United States or from England. The labour supply was abundant prior to the war, but at present considerable difficulty would be experienced in obtaining suitable help.

Crowsnest Pass. Locations in the Crowsnest pass offer the advantage of the cheapest supply of coal in British Columbia. The distance from the Kootenay zinc mines is between 275 and 325 miles. The distance from the Pacific coast is about 800 miles. Prior to the war labour was abundant, but conditions have not been such as to encourage local industries, owing to the dominance of certain foreign-controlled labour unions and the frequency of strikes. Suitable fire clays are not known to occur locally. It is possible that certain clays in southern Saskatchewan may prove to be suitable for fire brick and retorts. This has yet to be demonstrated. At present retort clays would have to be imported from St. Louis, Missouri.

Alberta Gas Fields. A third possible location is in the vicinity of one of the Alberta gas fields. The two principal fields are the Medicine Hat field, and the Bow Island gas field.[1] The Medicine Hat field is located about 475 to 525 miles from the British Columbia zinc mines. The Bow Island field is nearer the mines by about 40 miles. Gas for fuel could be obtained at a satisfactory rate, but there is no certainty of the permanence of the supply. Coal for reduction purposes would have to be brought from Bankhead or the Crowsnest. The latter locality could also supply coke breeze. The labour would have to be brought to either locality and trained. With respect to fire clays and retort clays, the same conditions hold as in the case of the Crowsnest pass.

[1] There are also certain private wells which indicate that there may be other gas well areas as yet undeveloped.

PROSPECTIVE COSTS OF ZINC SMELTING IN WESTERN CANADA.

Construction costs.

It is not possible to arrive at any certain figure as to the probable cost of erecting a zinc smelter in Canada without preparing detailed plans, ascertaining the unit prices at which all the materials required can be secured, and estimating the costs of construction, labour, and overhead. For general purposes it will be sufficient to assume that a Canadian smelting plant using coal would cost at the present time about $25.00 per yearly ton of capacity, and a gas plant would cost about $12 per yearly ton. A year or more from now, with a decline in the metal markets, and a decrease in the cost of structural materials it is to be anticipated that these costs would be about $20.00 and $10.00 per ton respectively. These costs are intended to include buildings of permanent construction, roasting furnaces, retort bl[illegible] pottery and producer plant, but do not include an acid plant.

Fuels.

The fuels available are coal and natural gas.

Vancouver Island coals are quoted at prices which range from $3.50 to $4.00 per ton f.o.b. cars for run-of-mine coal, prices which are prohibitive for a zinc smeltery. Some pea coal is sold at $3.25 per ton. According to a report on the Conservation of Coal, issued by the Conservation Commission,[1] from 24 to 34 per cent of the coal mined at some of the Vancouver Island collieries is wasted in treatment, and the total tonnage wasted is very large. It should be practicable to wash this waste product to obtain a fuel suitable for use in gas producers at a cost of not more than one dollar per ton. This, however, is a problem that has not been investigated. Some of this slack coal is stated to have been marketed at prices ranging from $1.60 to $2.00 per ton.

Crowsnest Pass Coals. There are seven companies now engaged in coal mining in the Crowsnest Pass area, and a number of others own mines which are at present idle. The Crow's Nest Pass Coal Company quote $2.50 per ton for run-of-mine coal f.o.b. cars at the mine. I understand that there were formerly legislative restrictions which provided for a maximum charge of $2.00 per ton for run-of-mine coal at the mines, and I am not informed as to whether these restrictions have been modified or withdrawn. At the present time the coal mined at the different collieries of this Company is screened, and all the fine coal, passing through a one inch screen, is converted into metallurgical coke in beehive ovens.

The other companies now operating in the district quote their coal at

[1] Conservation of Coal in Canada, by. W J. Dick, Commission of Conservation, Canada, 1914, pp. 188 and 193.

prices which range from $2.00 to $2.50 per ton for run-of-mine coal f.o.b. cars at the mine. If actual business offered it is probable that coal suitable for gas producers could be obtained at $1.75 per ton. The calorific value of this slack coal would be about 12,000 B.Th.U.[1]

Lethbridge Coal. Several companies are producing a lignitic coal in the vicinity of Lethbridge. The heating value of this coal is less than that of the coals produced in the Crowsnest pass, being only about 10,000 B.Th.U. as against 13,000 B.Th.U. yielded by coals from the Crowsnest Pass area. It is, however, suitable for use in gas producers and can be obtained at a reasonable price.

Mine slack contains too large a proportion of fire clay to be a suitable fuel, but a certain amount of slack is produced from the breaking of the lump coal during handling. This material is quoted at 75 cents per ton f.o.b. cars at the mine, and contains about 19% of ash and 8% of moisture. The heating value of this slack is about 9,000 B.Th.U., but the tonnage at present available is small.

Anthracite Coals. Anthracite coals are produced from two districts in Alberta—at Canmore and at Bankhead. The Canmore Coal Company pick and wash their coal and ship it as run-of-mine. The coal produced at the Bankhead mines is screened and sized for the market. In the process of treatment about 35 per cent of the output is recovered as dust. This dust is made into briquettes at the mine and a very considerable market for the briquettes has developed. Dick states[2] that the average cost of production of these briquettes is $3.10 per ton, allowing $1.00 for the cost of the dust. The Company quotes this dust at $1.50 per ton f.o.b. cars at the mine, and also states that their briquettes trade, which is largely contracted for, requires all the dust that they make.

By-Product Coke Oven Gas. The production and output of metallurgical coke in British Columbia, during the last four years have been as follows:—

	Production.	Output.
1912	299,773 tons.	296,052 tons.
1913	321,771 "	319,860 "
1914	265,198 "	263,318 "
1915	275,523 "	275,375 "

All of this coke was made in beehive ovens, and all by-products were wasted. There are about 1,636 of these ovens available in the Crowsnest Pass area, in addition to two batteries (of 25 ovens each) of the Belgian retort type coke oven at Lisle, and 101 Mitchell rectangular ovens at Passburg. The ordinary beehive ovens yield about 2 tons of 48 hour coke per day on the average, this being about 62·5% of the weight of the

[1] A correspondent states that coal suitable for gas producers could be secured at $1.25 per ton, if any real business offered.

[2] Conservation of Coals in Canada, p. 123.

coal charged. The batteries of the Belgian retort type had, when in operation, an average output of 150 tons of 48 hours coke daily, the yield being about 69% of the weight of the coals charged. At the present time only about 1,000 of the beehive ovens are in operation; all the other ovens are idle.

No detailed studies of the results that could be obtained by treating Crowsnest Pass coals in a by-product plant are available, and therefore, in making a preliminary study of the possibilities in this direction in relation to a zinc smelting industry, it is necessary to use data of general application.[1]

It may be safely assumed that the gas produced from British Columbia coking coals in by-product ovens would amount to 5,000 cubic feet per ton with a heating value of 500 B.Th.U. per cubic foot. These are minimum figures. At the present time at least 600,000 tons of coal per annum are being converted into metallurgical coke, or approximately 1,600 tons per day. The gas yield from this would be approximately 8,000,000 cubic feet per day. About 100,000 cubic feet of this by-product coke oven gas would be required to smelt one ton of average zinc ore in a retort plant. This represents an output of 800 pounds of zinc from a 50 per cent zinc-ore, with only 80% recovery, or 250,000 cubic feet of gas per daily ton of spelter produced. A daily production of twenty tons of zinc would therefore require about 5,000,000 cubic feet of this gas, as a maximum quantity; in practice probably much less.

By-product coke ovens have not been installed in western Canada for various reasons. The reason usually assigned is that there is no market for the by-products and therefore the greater cost of installation is not justified. In addition the irregular demand for metallurgical coke would not make it profitable to establish an extensive plant of this type on account of the danger of shut downs.

So far as the public is concerned this problem has not been investigated. Admittedly the annual wastage in valuable by-products amounts to a very large sum.

With regard to a permanent market for coke, there is one possible market which does not appear to have received the attention it deserves. Coke as a fuel for household purposes is much superior to the western soft coals and lignites now used for this purpose. The growing population of the districts between Lake Winnipeg and the Rocky mountains should afford a large and permanent market for this class of fuel for domestic purposes, were the people educated to its use.

The practically permanent copper smelting industries of British Columbia and the adjacent state of Washington and the prospective domestic market ought to assure a fixed minimum demand for metallurgical

[1] *See* Products and By-Products of Coal, by Edgar Stansfield and F. E. Carter, Mines Branch, 1915.
The Distillation of Coal, by F. E. Lucas, Trans. Min. Soc., Nova Scotia, April, 1914, pp. 124–134.
The Manufacture of Coke, by F. E. Lucas, Bulletin A.I.M.E., No. 71, p. 1324.
Conservation of Coal in Canada, by W. J. Dick, Commission of Conservation, 1914, pp. 25–32.

coke. It should be possible to arrange for a by-product coking plant to care for this fixed minimum and to assure continuous operation of the coke plant. The fluctuating demand could be met by using beehive ovens as at present or by providing storage capacity. While some such arrangement would be practicable under public ownership, or under the ownership of a single corporation whose various departments would co-operate, under existing conditions it is very doubtful if any such arrangement could be made without Government intervention in the interests of conservation.

By-product gas would be an excellent fuel for the zinc smelter. It has never been used for that purpose in America and possibly some slight difficulties might be experienced at first. The great danger to the zinc smelter would be possible shut downs—even a shortage of supply for half an hour would have serious consequences.

Natural Gas. Natural gas is being produced in commercial quantities in two localities—in the Medicine Hat field and in the Bow Island field.

The following information with respect to the Medicine Hat gas field was supplied to the commission acting for the Imperial Munitions Board in 1915, in connexion with the supply of copper and zinc[1]:—

The gas area exploited extends from Bassano, ninety-five miles west of Medicine Hat to Dunmore, nine miles east. The flow at Dunmore is the same as at Medicine Hat, so that it is probable that the field extends a considerable distance beyond that point. Large flows have also been found at Bow Island. The northern limit has not been defined as drilling has only been done close to the city. Medicine Hat gas is found at three different depths. The first is at 125 feet and this gas is damp; the second is at 625 feet and this gas also carries a little moisture but at one time, was used as source of supply. The pressure of this gas is about 250 lbs. per square inch. The city is now supplied with gas from a depth of 950 feet to 1,050 feet, and the wells drilled to this stratum have a capacity from 2,500,000 cubic feet to 4,000,000 cubic feet per 25 hours. The rock pressure at this depth is about 585 lbs. per square inch, and the gas contains no moisture. The cost of drilling one of these wells is about $10,000. Medicine Hat has been using gas for about 14 years.

The analysis of the gas is as follows:

Methane	99·49%
Hydrogen	·51%[2]
Oxygen	a trace
B.T.U. per cubic foot	1,100

During the year 1913, the domestic consumption amounted to 750,000,000 cubic feet, while the industrial consumption was about 900,000,000 cubic feet extra. The gas is sold for domestic purposes at the rate of 13½c per 1,000 cubic feet and for industrial consumption at 5c per 1,000 cubic feet.[3]

For distribution throughout the city, the gas is first passed through a high pressure and then through a low pressure regulating station. The gas, on coming from the wells, passes through a high pressure regulating station, where the pressure is reduced to about 40 lbs., and mains run through the city carrying gas at this pressure on which are located low pressure regulating stations which again reduce the pressure to about 6 ozs., at which pressure it is distributed through low pressure mains to the consumer. For manufacturers, regulators are installed to give whatever pressure may be required for the particular purposes to which it is applied.

There are at the present time 25 wells drilled in the vicinity of Medicine Hat. The average capacity of these wells is stated to be 3,000,000 cubic feet each per 24 hours, on the authority of Robert S. Winter, gas superintendent of the city of Medicine Hat, and the rock pressure is placed at

[1] Report of this Commission, p. 134.
[2] The presence of hydrogen in natural gas is very doubtful.
[3] The price ranges from 5 cents to half a cent per 1,000, according to the amount used.

555 pounds per square inch. Three of the wells have a casing, 4⅝ inches in diameter where it enters the gas sands; two have an 8" casing at this point, and nine have a 6" casing; the records of the other eleven wells are not available. The present consumption is at the rate of approximately 1,380,000 cubic feet for domestic purposes, and 7,100,000 cubic feet for manufacturing purposes, per 24 hours.

With respect to the use of Medicine Hat gas for zinc smelting purposes, I am advised that the city of Medicine Hat entered into an agreement during the present summer to supply gas for this purpose. This agreement expired on July 30th but was renewed for a further period of two months. Under the agreement the city undertook to supply gas, water and electric power for a period of twenty years, subject always to a failure of the supply. Gas was to be supplied for a period of ten years at one fifth of one cent per 1,000 cubic feet, and one cent per 1,000 cubic feet for the remaining ten years. Water was to be supplied at 5 cents per 1,000 gallons, and electric energy at one cent per kilowatt hour, provided always that the price quoted covered the cost price to the city, as determined from time to time.

The producing gas wells in the Bow Island field belong to the Canadian Western Natural Gas, Light, Heat, and Power Company, with head office at Calgary, Alberta. The latest information available credits this Company with 64 wells drilled, only two of which had been non-productive. They own about 200 miles of pipe line of a capacity of about 40,000,000 cubic feet per day, and supply gas to the city of Calgary and to a number of other communities south of Calgary.

This Company is prepared to offer a supply of natural gas at a net rate of 15 cents per 1,000 cubic feet per day, provided that more than 15,000,000 cubic feet altogether are used during each month. Should a lesser quantity than 15,000,000 cubic feet be used, the rates would then be 17 cents per 1,000 cubic feet for the first 4,000,000 cubic feet, 16 cents per 1,000 cubic feet for the next 6,000,000 cubic feet, and 15 cents per 1,000 cubic feet for the last 5,000,000 cubic feet. These rates are their regular industrial and power rates to each consumer. They will not guarantee the supply of any amount of gas for any length of time to industrial consumers of the type of a zinc smelting plant. Their franchises with the cities and towns, which they now supply with gas, give preference to domestic consumers in case of shortage and they will enter into no contract with an industrial consumer which will interfere with this provision in their franchises.

It is not necessary, in this report, to comment at any length on the proposed use of the natural gas in the Medicine Hat field for zinc smelting purposes. It suffices to say that the community would benefit most by carefully conserving its supply for domestic purposes only. This is well recognized by competent operators and is reflected in the attitude of the only large producing corporation in Alberta in quoting prices for a zinc smelting industry. The temporary benefit that would accrue to the city

of Medicine Hat for the relatively few years that a zinc smelter could be operated near that town would not begin to compensate the community as a whole for the losses that it will eventually experience if it permits its most valuable natural fuel to be wasted in a zinc smelting plant, largely for the benefit of the non-resident private interests operating the plant, and for speculators in land values.

Reducing Materials.

The reducing materials that would be available for a zinc smelter located in British Columbia or southern Alberta are coke breeze and anthracite dust.

Coke breeze could be obtained from the coke oven plants in the Crowsnest pass, about 40 lbs. of breeze being produced per ton of coke. At present a portion of the breeze that results from handling the coke is washed and marketed at a price of $2.50 per ton. There is, however, a considerable amount produced that is, at present, a waste product. The coke produced in the Crowsnest Pass area is all used for metallurgical work, chiefly in the copper and lead smelters of British Columbia, only a small percentage being sold in the United States. The demand for metallurgical coke fluctuates greatly, and there is a corresponding fluctuation in the amount of coke and coke breeze produced. This variation in demand is also assigned by one of the principal producers of coke as a controlling factor which would make it unprofitable to install by-product coke ovens. There are over 600 ovens with a combined capacity of about 1,200 tons per day lying idle at this date.

The coke ovens on Vancouver island are not in operation, and coke breeze would have to be imported from the mainland, from the state of Washington, or from Australia.

Anthracitic dust, produced from the semi-anthracite coals of the Cascade coal basin would probably prove to be a suitable reducing material. The dust, now made into briquettes at Bankhead, as already noted, is quoted at $1.50 per ton, but the demand created by the existing market for briquettes is such that very little of it would be available.

Dead coals. Many of the coal seams in the Crowsnest Pass area outcrop at the surface, and it would be possible to obtain weathered coal from some of them. At present there is no market for this product and none is produced. The nearest approach to dead coal is the coal stripped from the upper portion of the coal bed at Corbin. Trials would be necessary to determine the suitability of this material for reduction purposes.

Retort Clays.

Practically all the zinc smelters in America obtain their retort clays from the St. Louis district in Missouri. As already noted these clays are

quoted at $2.00 per ton, f.o.b. cars St. Louis. The freight rate on this material from St. Louis to St. Paul is $1.70 per ton of 2,000 pounds. The freight rates from St. Paul to Bow Island, Frank, and Fernie are respectively $5.80, $6.20, and $6.80 per ton. The freight cost per ton of St. Louis clay, at the three points mentioned, would thus be $9.50, $9.90, and $10.50. The rate from St. Paul to the coast has not been ascertained, but it may be assumed that St. Louis clay would cost at least $12.00 per ton f.o.b. docks at Vancouver Island points.

Assuming that about one eighth of a ton of clay is required per ton of green ore treated the clay cost of smelting at the three points mentioned would be respectively $1.20, $1.24, and $1.31.

High grade fire clays are reported to occur in southern Saskatchewan. Their suitability for use as retort clays can only be ascertained by trial on a commercial scale and this has not yet been done. Saskatchewan clays could be laid down at Bow island for $2.60 per ton freight. The rates to Frank and Fernie would be $3.10 and $3.30 per ton respectively. The cost of the clays at the pit need not exceed $1.50 per ton, and possibly might be only $1.00.

Labour Costs.

There is no labour, skilled in the zinc industry, available in Canada. At present even general labour is very scarce and wages are correspondingly high. Just what wages would have to be paid by a newly organized zinc smelter it is impossible to ascertain. In discussing this question in 1906, Ingalls reckoned an average wage of $3.00 in zinc smelting in Canada and an average wage of $2.00 in the United States.[1] The wages in the zinc industry in the United States were stated to range from 15 to 25 cents per hour, while the wages at the lead smelters in Canada ranged from 25 to 50 cents per hour. As already noted in a previous paragraph the daily wage at United States smelting centres now ranges from 25 cents to about 55 cents per hour. In the copper and lead smelting industries of British Columbia wages range from $3.00 per day of nine hours for common labour to $4.50 per day for certain trades. It may therefore be assumed that the scale of wages for a zinc smelter in western Canada would probably be the same as that which prevails in the lead and copper industries.

Men skilled in the industry are not at present available. Very considerable difficulty can be anticipated at present in procuring the services of a competent head furnace man. Such a man would probably command from $400.00 to $500.00 per month in wages. With the decline of the zinc market, and the consequent diminution in the output of zinc and the closing of some of the United States zinc smelters, it is to be anticipated that skilled men of this type will be available at a much lower wage next year or later.

[1] Zinc Commission Report, p. 54.

If the average wage in the zinc industry in the United States in 1906 was $2.00, it is probably about $3.00 to-day. Corresponding to this the average wage that would have to be paid in Canada would be about $3.50. Assuming that the smelting of 2,000 pounds of green ore requires approximately the labour of $2\frac{1}{2}$ to $2\frac{3}{8}$ men for one day, the labour cost per ton of ore smelted in Canada would amount to about $8.30 per ton.

The accompanying schedule showing the wage scales in force at Trail in 1916 will serve to give a fair idea of the wage scales that would prevail at a zinc smelting plant in western Canada, if one were established.

Consolidated Mining and Smelting Company of Canada, Limited.[1]

Wage Scale, Smelter. Corrected to July 1, 1916.

	Hours per day	[2]First Scale	[3]Second Scale	[4]Third Scale
Copper Furnaces—				
Furnaceman	8	$4.00	$4.25	$4.40
Feeder	8	4.00	4.25	4.40
Loader or 2nd feeder	8	3.50	3.75	3.90
Pot pullers	8	3.50	3.75	3.90
Slag spout man	8	3.00	3.25	3.40
Clay man	8	3.00	3.25	3.40
Feed floor sweeper	8	3.00	3.25	3.40
Flue dust man	8	3.00	3.25	3.40
Craneman	8	3.65	3.90	4.05
Labourers	8	2.75	3.00	3.15
Dump switchmen	8	3.00	3.25	3.40
Tapper	8	3.50	3.75	3.90
Lead Furnaces—				
Furnaceman	8	4.00	4.25	4.40
Feeder	8	4.00	4.25	4.40
Loader	8	3.25	3.50	3.65
Slag tapper	8	3.50	3.75	3.90
Slag spout man	8	3.25	3.50	3.65
Bullion men	8	3.00	3.25	3.40
Flue dust men	8	3.00	3.25	3.40
Cranemen	8	3.65	3.90	4.05
Crane chaser	8	3.00	3.25	3.40
Labourers	8	2.75	3.00	3.15
Feed floor sweeper	8	3.00	3.25	3.40
Casting Lead Anodes—				
Lead caster	8	$3.25	$3.50	$3.65
Matte Plant—				
Crusherman	8	3.25	3.50	3.65
Wheeling to crusher	8	3.00	3.25	3.40
Dumper Kilker cars	8	3.00	3.25	3.40
Labourers	8	2.75	3.00	3.15
Slag Breaker—				
Operator	8	3.25	3.50	3.65
Helper	8	3.00	3.25	3.40
H. & H. Roasters—				
Firemen	8	3.50	3.75	3.90
Converter tender	8	3.00	3.25	3.40
Converter crane chaser	8	3.25	3.50	3.65
Converter helpers	8	2.75	3.00	3.15
Ore wheelers	8	2.75	3.00	3.15
Crusherman	8	3.25	3.50	3.65
Crusherman helper	8	3.00	3.25	3.40
Scaleman	8	3.00	3.25	3.40
Labourers	8	2.75	3.00	3.15
Cranemen	8	3.65	3.90	4.05
Hoistman	8	3.25	3.50	3.65

[1] Republished from "A Record of the Commission appointed to investigate the feasibility of Refining Copper and Producing Metallic Zinc on a Commercial Scale in the Dominion of Canada," March to August, 1915.

[2] *First Scale*—Scale in force April 30th, 1916.

[3] *Second Scale*—War Scale went into effect May 1st, 1916, and to continue in force for the duration of the war, unless the prices of metals drop sufficiently to lower the mine scales, when 50% of the reduction made in either or both the lead or copper scales will be made on the smelter scale.

[4] *Third Scale*—This scale became effective July 1st, 1916, for July, August, and September, a flat increase of 15c per man per day on the second scale; this increase to continue in effect as long as copper remains above 25c Montreal, and lead remains above 8c Montreal. When copper is between 22c and 25c and lead between 7c and 8c, this increase will be 10c per man per day, and when copper is between 18c and 22c and lead is between 6c and 7c, this increase will be 5c per man per day.

	Hours per day	First Scale.	Second Scale.	Third Scale.
Wedge Roasters—				
Furnacemen	8	4.00	4.25	4.40
Scalemen	8	3.00	3.25	3.40
Labourers	8	2.75	3.00	3.15
Dwight and Lloyd Roasters—				
Furnacemen	8	4.00	4.25	4.40
Helper	8	3.00	3.25	3.40
Labourers	8	2.75	3.00	3.15
Sample Mill—Day—				
Millwright	8	4.50	4.75	4.90
Millman, head	8	3.50	3.75	3.90
Millmen	8	3.00	3.25	3.40
Labourers	8	2.75	3.00	3.15
Crusherman	8	3.00	3.25	3.40
Sample cutter	8	3.50	3.75	3.90
Cotterell Plant—				
Operator	8	3.50	3.75	3.90
Handling fume	8	3.00	3.25	3.40
Sample Mill—Night—				
Foreman	8	4.00	4.25	4.40
Millmen	8	3.00	3.25	3.40
Crusherman	8	3.00	3.25	3.40
Labourers	8	2.75	3.00	3.15
Mechanical Department—				
Foreman machine shop	9	5.00	5.25	5.40
Foreman boilermaker	9	5.00	5.25	5.40
Machinists	9	4.00 to 4.50	4.25 to 4.75	4.40 to 4.90
Machinists' helpers	9	3.00 to 3.25	3.25 to 3.50	3.40 to 3.65
Boilermakers	9	4.00	4.25	4.40
Boilermakers' helpers	9	3.00	3.25	3.40
Flanger	9	4.25	4.50	4.65
Flanger's helpers	9	3.25	3.50	3.65
Welder	9	4.00	4.25	4.40
Welder's helper	9	3.00	3.25	3.40
Blacksmith	9	4.00 to 4.50	4.25 to 4.75	4.40 to 4.90
Blacksmith's helper	9	3.25	3.50	3.65
Car repairers	9	3.25 to 3.50	3.50 to 3.75	3.65 to 3.90
Drillers	9	3.25	3.50	3.65
Pipe fitters	9	3.50 to 4.50	3.75 to 4.75	3.90 to 4.90
Pipe fitters' helpers	9	3.00 to 3.50	3.25 to 3.75	3.40 to 3.90
Chain gang foreman	9	4.50	4.75	4.90
Chain gang labourers	9	2.75 to 3.00	3.00 to 3.25	3.15 to 3.40
Blower room tender	8	4.00	4.25	4.40
Oilers	8	3.25	3.50	3.65
Labourers	9	2.75	3.00	3.75
Electrical Department—				
Electricians	9	3.50 to 4.50	3.75 to 4.75	3.90 to 4.90
Electricians' helpers	9	3.00	3.25	3.40
Labourers	9	2.75	3.00	3.15
Linemen	9	3.50	3.75	3.90
Motormen	8–9	3.25	3.50	3.65
Carpenters—				
Carpenters	9	4.00 to 4.50	4.25 to 4.75	4.40 to 4.90
Carpenters' helpers	9	3.00	3.25	3.40
Labourers	9	2.75	3.00	3.15
Track layers	9	3.50	3.75	3.90
Track layers' helpers	9	3.00	3.25	3.40
Flume foreman	9	4.00	4.25	4.40
Flume watchman	12	3.00	3.25	3.40
Teamster	9	3.25	3.50	3.65

	Hours per day.	First Scale	Second Scale	Third Scale
Masons—				
Bricklayers	9	5.00	5.25	5.40
Bricklayer's helpers	9	3.00	3.25	3.40
Labourers	9	2.75	3.00	3.15
Lead Refinery—				
Tankroom foreman	8	3.50	3.75	3.90
Tankroom labour	8	2.75	3.00	3.15
Short circuit men	8	3.50	3.75	3.90
Short circuit men helpers	8	2.75	3.00	3.15
Sheet hanger	8	3.00	3.25	3.40
Sheet hanger helpers	8	2.75	3.00	3.15
Sheet hanger boys	8	1.75	2.00	2.15
Sheet caster	8	2.75	3.00	3.15
Motor tender	8	3.50	3.75	3.90
Cranemen	8	3.25	3.50	3.65
Crane chasers	8	3.00	3.25	3.40
Scrap washers	8	3.00	3.25	3.40
Slimes Plant—				
Shift bosses	8	3.50	3.75	3.90
Parters and furnacemen	8	3.00	3.25	3.40
Roastermen	8	2.75	3.00	3.15
All labour	8	2.75	3.00	3.15
Vitriol Plant—				
Operating men	9	3.00	3.25	3.40
Labour	9	2.75	3.00	3.15
Machinist and pipe fitter	9	4.00	4.25	4.40
Slime washer (contract) at $3.75 per day.				

The following additional wage scales are also of interest:—

Wage Scales in the Slocan District, British Columbia.[1]

Eight hour shifts.			
Miner	$4.00	Trammer	$4.00 to $4.50
Stoper	$3.50 to $4.00	Blacksmith	3.50 to 4.00
Mucker	3.50	Timberman	$4.00
Nine-hour shifts—			
Blacksmith	4.50	Engineer	$4.00 to $4.50
Blacksmith's helper	$3.50 to $4.00	Ore sorter	$3.50
Carpenter	4.00	Car loader	3.50
Timber framer	3.50	Labourer	3.50
Compressorman	4.50 (10 hrs.)		
Ten to twelve-hour shifts—			
Mill foreman	$5.00 to $6.00	Tableman	4.00
Jig man, day	4.00 to 4.50	Crusherman	3.75 to 4.00
Jig man, night	5.00	Labourer	3.50

[1] Underground shifts usually work eight hours. Surface shifts are usually nine hours. Some few occupations require longer shifts, ten to twelve hours.

Wage Scales in Rossland Camp.[1]

Miner	$4.00	Hoist engineer	$4.75
Miner, sinking	4.50	Compressor engineer	4.25
Mucker	3.50	Blacksmith	4.25
Timberman	4.00	Blacksmith, helper	3.75
Timberman shafts	4.50	Machinist	4.25
Trackman	4.00	Machinist, helper	3.50 to 3.75
Pipeman	4.00	Ore sorter	3.25
Pipeman helpers	3.25 to 3.75	Labourer, surface	3.25
Pumpman	4.25	Lumberyard man	3.25 to 3.50
Motorman	3.75	Timber framer	4.00
Blaster	4.50	Timber framer, helper	3.50
Blaster, helper	4.00	Carpenter	4.25
Blaster, on boulders	4.00	Nipper	3.75
Skiptender	4.00		

Wage Scales in the Joplin District, Missouri.[2]

Ground boss	$5.00 to $7.00	Shoveller,[3] in sheet ground	11c per can.
Hoistman, shaft (8 hrs.)	4.00	Mules[4]	$4.00
Hoistman, incline hoist	3.75	Hookers	4.00
Hoistman, in sheet ground	4.75	Gas engine man	$4.00 to $5.00
Miner, at face	4.00	Fireman (12 hrs.)	4.00
Miner, in sheet ground	4.00	Jigman	5.00 to 6.00
Miner, helper, in sheet ground	3.75	Tableman	3.75
Shoveller[3], piece work	7·5c per can.	Rock crusher	3.25 to 3.50

AVAILABLE ORE SUPPLY.

General.

The character of the British Columbia zinc ores available for treatment is well known[5]. The greater portion of the ore produced in the Kootenays consists of a mixture of zinc blende and galena, usually contains silver, and very frequently pyrites.

In many of the mines the ores are complex silver-lead ores containing zinc blende, which has to be removed to make the lead ore marketable. Zinc ore from such a mine is in the nature of a by-product; it usually contains a considerable amount of silver, however. A few mines produce zinc blende, with which is associated only a small amount of lead. During the last two years one mine has been producing a considerable tonnage of carbonate ore containing some silicates, obviously the products of the partial decomposition of large sulphide ore bodies. This product is relatively high in iron and, as shipped, contains only about 30% of zinc or less.

Zinc ores, prepared for shipment in British Columbia, consist in part of hand-sorted lump ore, and in part of mill concentrates.

The mill concentrates produced here were formerly almost wholly recovered on jigs and tables. Recently two mills have introduced flotation units, and one mill is introducing partial roasting and magnetic concentra-

[1] Underground shifts eight hours, surface nine hours.

[2] The present scale is a sliding scale based on $60-$70 ore. For every $10.00 increase the wages are to be increased 25 cents per day.

[3] A shoveller will average 125 to 135 cans per day. The nominal capacity is 1,000 lbs., the actual delivery 800-900 lbs. The cans used in the sheet ground are slightly larger in capacity. One hoistman handles about 800 cans per day.

[4] A local name applied to the man who shifts the cans from the shoveller to the bottom of the shaft.

[5] For a fuller discussion see Report of the Zinc Commission, p. 13.

tion. Other mills are preparing to follow suit, and it is to be expected that there will be a considerable improvement in the grade of the mill concentrates available for treatment.

Output.

Annual Output. The annual output of zinc ore from Canadian mines, and its metallic contents are shown in the statistical tables which accompany this report. It will be noted that the tonnage of ore produced during different years has varied considerably. The production in 1914 was 10,893 tons containing 9,101,460 pounds of zinc, of which not more than 85% would be recovered. In 1915 the production was 14,895 tons containing 12,231,439 pounds of zinc, of which not more than 85% would be recovered. The returns of shipments for the first few months of the present year, 1916, do not suggest that there will be any material increase in the output this year.

Nature of the Ores. The nature of the ore bodies in the silver-lead-zinc mines of the Kootenays was described at length in the report of the Zinc Commission,[1] and the practical impossibility of preparing any reliable estimate of the ore available was pointed out. Lack of development, together with the irregularity of the ore bodies, made it impossible to formulate any reliable estimate of the producing capacity of the mines. The conclusion was reached that it was probable that 15,000 tons of zinc ore of 50 per cent grade would be a liberal estimate for the productive capacity of the Slocan. The mines of the Ainsworth camp were credited with an ability to produce 54 tons daily of zinc ore of 50% grade, and might in the course of a year or so be able to attain an output of 100 tons daily of 45 to 50% grade, if the extensive deposits were mined and milled on a scale commensurate with their magnitude. These estimates correspond to 16,000 tons per annum and 30,000 tons per annum respectively. Needless to say, these mines have never yet attained this rate of production.

Future possibilities. The annual output of these mines must depend chiefly upon the tonnage of ore made available for mining, the milling capacity available for treating the ore mined, and the efficiency of the methods of concentration employed.

With respect to the tonnage of ore available it has not been the practice of the majority of the zinc producing mines in British Columbia to carry on development work well ahead of mining. In the greater number of cases, the ore reserves are usually only equal to a few months' output; there are, however, a few notable exceptions. It is therefore impossible to make any reliable estimate of the ore reserves.

During the course of the present investigation it was not practicable to make a personal estimate of the tonnages of ore developed or partially developed. As an alternative all the mine operators who have produced

[1] Zinc Commission Report, pages 42 to 51.

zinc ores within the last few years were requested to furnish statements of their ore reserves, their possible daily output, and other data with respect to their prospective output. The returns received have been correlated and show that there is about 550,000 tons of zinc ore supposed by the owners to be available in the Kootenays. This ore is expected to yield at least 56,000,000 pounds of zinc and 6,600,000 ounces of silver. This estimate does not include any prospective output from the Hudson Bay mine near Salmo, nor from any of the mines belonging to the Consolidated Mining and Smelting Company of Canada. The Hudson Bay mine undoubtedly contains a large tonnage of low grade zinc ore, but the present amount of development work does not warrant any estimate of the available tonnage. The Sullivan mine, belonging to the Consolidated Mining and Smelting Company of Canada, is known to contain over 1,000,000 tons of ore, containing about 20 to 25% zinc, besides lead and silver, but the treatment of this ore involves the use of special processes. There are in addition a number of excellent prospects in the Ainsworth and Slocan districts, and elsewhere, on which little development work has been done, and whose probable output could not, therefore, be included in this estimate. The figures given above are therefore to be regarded as a minimum.

Milling capacity. With respect to the milling capacity available for treating lead-zinc ores, the accompanying table shows the conditions in 1916. There were in operation ten mills with a total rated capacity of about 975 tons of ore per day. Three mills with a rated capacity of 365 tons per day, exclusive of the St. Eugene mill, were idle, two mills were actually under construction, and the site had been cleared and material was being assembled for one of the three other mills that were planned. One small mill was undergoing changes intended to increase its capacity.

With respect to the efficiency of the mills in operation there appears to be great room for improvement. Only two mills are equipped with flotation units, one mill, under construction, proposes to install them, and one mill, under construction, is installing magnetic separation. At present to the majority of operators zinc ore is merely a nuisance, which has to be removed to prevent the penalizing of their lead ores by the smelter. Since the zinc ore removed contains a considerable amount of silver, it is profitable to save it and market it, even against adverse conditions of long haulage, high freights, and low returns for both silver and zinc. Even under these existing conditions it is probable that it would prove profitable to introduce flotation and magnetic separation in more mills. The present tailing losses would be materially reduced, and the grade of the shipping product would be increased, with a corresponding saving in freight rates on a lower tonnage and a better market price for a higher grade product.

The subject of the mechanical concentration of zinc ores received the very careful attention of the Zinc Commission in 1905, and the sections of their report dealing with this subject are worthy of receiving closer attention

from the zinc producers of the Kootenays.[1] The discussion on magnetic separation and the results of the experimental work on Kootenay ores, carried out under the direction of the Commission, are particularly applicable to the existing conditions. The general conclusions with respect to the application of magnetic separation to British Columbia ores is as follows[2]:—

The possibility of enriching the zinc ores of British Columbia to a high degree by magnetic separation has been thoroughly demonstrated by the tests conducted by the Commission, which have been hereinbefore summarized. The ores tested are of wide variety and represent all of the classes that the mines of the Province are at present capable of producing. In every case it has been possible to produce a zinc concentrate assaying upward of 40% zinc; in many cases concentrates assaying about 50% zinc; and in a few cases concentrates assaying as high as 57% zinc.

Conclusions. At the present time there is not a sufficient tonnage of zinc ore of suitable grade produced in Canada to support an ordinary zinc smelting plant of 25,000 tons capacity per annum. The zinc content of the concentrates as now shipped is much lower than it should be, owing to imperfect methods of concentration. Several of the principal producing companies are under contract for a term of years to supply ore to smelters in the United States. This portion of the British Columbia output of zinc ore could be made available for a Canadian plant if the export were prohibited or were even made unprofitable by export regulations. Some such action has in fact been anticipated in some cases as the contracts contain a clause providing for government interference either from Canada or the United States. This clause usually provides for the suspension of the contract for the period of time during which the anticipated obstruction, of whatever kind may exist.

Other Ore Supplies.

While western Canada has not, up to the present, produced enough zinc ore annually to support a smelter of the minimum capacity that could be operated commercially, the possibility of supplementing the home output with imported ores has not received the attention it deserves.

Prior to the war Australia exported more than half a million tons of zinc concentrates annually to European points for treatment. Since the war began force of circumstances has materially curtailed this output, and provision is being made to treat the greater portion of the future output at home. However, a very considerable tonnage of Australian concentrates found its way to zinc smelting plants in Kansas, Oklahoma, and Pennsylvania, entering the United States via San Francisco and via the Panama and Galveston. I have not been able to ascertain the freight costs per ton on any of these importations. A Japanese organization is also credited with starting a new zinc smelting plant, of 40,000 tons annual capacity, for the treatment of these concentrates. It would seem that it would have been

[1] Zinc Commission Report, pp. 74–121.
[2] Zinc Commission Report, p. 99.

Zinc Concentrating Mills in British Columbia, 1916.

Name of Mine or Company.	Location.	Rated capacity tons per 24 hours.	Machinery used.	Remarks.
Blue Bell	Riondel	250	Jigs, tables	Does not save zinc concentrates.
Cork Province	Zwicky	60	Jigs, tables, vanners	
Florence	Ainsworth	300	Jigs, tables, flotation	
Galena Farm	Silverton	100	Jigs, tables	Mill planned and partly under construction
Hewitt	Silverton	140	Jigs, tables, mineral separation	Propose to install flotation later.
Highland	Ainsworth	100	Jigs, tables	Mill idle at present
Hudson Bay	Salmo			Washer planned for treating earth carbonates.
Kootenay Ore	Kaslo	100	Jigs, tables, mineral separation	Under construction
Treatment Company		40	Tube roaster and magnetic separators	Dings magnetic separators, to treat concentrates.
Krao	Ainsworth			Mill planned.
Lanark	Illecillewaet	50	Jigs, tables	Mill planned.
Molly Gibson		100	Jigs, tables	Idle during winter.
Monarch	Field	40	Jigs, tables	Undergoing alteration, present capacity below 40 tons per day.
Rambler-Cariboo	Three Forks	75	Jigs, tables	
Roseberry Customs Concentrator	Roseberry	40	Jigs, tables	
Ruth-Hope	Sandon	100	Jigs, tables	
St. Eugene	Moyie			Closed.
Slocan-Star	Sandon	100	Jigs, tables	
Standard	Silverton	120	Jigs, tables, flotation	Both Mineral Separation and Callow machines used.
Surprise	Sandon	100	Jigs, tables	Re-building Ivanhoe mill.
Van Roi	Silverton	125	Jigs, tables	Closed at present.

[illegible] was to have arranged to treat Australian concentrates at some p[illegible] on the coast of Vancouver island, near some of the coal mines. All the [illegible] British Columbia ores could have been assembled at the same point. During the period of high prices for spelter it would have been possible to have operated commercially at any one of several points on the British Columbia coast. Operation under normal conditions would be impossible unless coal could be obtained at more reasonable rates than those which now prevail.

Another possible source of supply for some zinc ores is the Coeur d'Alene region of Idaho, and the state of Montana. At present ores from the Coeur d'Alene region are shipped to Kansas and Oklahoma points at a cost of about $9.00 per ton for freight. Montana ore pays a freight charge of about $7.00 per ton. At present there is no through traffic in ores of this class to the Crowsnest Pass district or to Alberta and definite rates cannot be obtained. On the basis of rates on lead ores from the Coeur d'Alene to Trail it may be assumed that a rate of $5.00 per ton or less could be obtained. Much of the ore from both the states of Idaho and Montana is at present sold under contract to smelters in the middle west. It should be possible, however, to obtain a considerable tonnage for shipment to a western Canadian point, if the need arose.

The accompanying table shows the annual output of zinc ores and concentrates for the states of Idaho and Montana for the years 1910–1914 inclusive. The tables have been compiled from the Mines Reports for Montana and Idaho, Mineral Resources of the United States, Part I, 1910–1914 inclusive.

OUTPUT OF ZINC ORE.

State of Montana.

Year.	Production of Zinc (Spelter).	Concentrates.	Crude ore.	Total tonnage of ore treated.
1910	31,638,184 lbs. (15,819 tons)	> 31,334,204 lbs.	> 303,980 lbs.	169,195*
1911	43,810,145 lbs. (21,905 tons)	[illegible] tons > 43,734,150 lbs.	128 tons* > 75,995 lbs.	225,586
1912	26,918,881 lbs. (13,459 tons)	32,947 tons > 26,792,550 lbs.	186 tons* > 126,331 lbs.	136,643*
1913	88,673,083 lbs. (44,337 tons)	105,524 tons > [illegible],595,842 lbs.	128 tons > 77,241 lbs.	311,455*
1914	111,580,544 lbs. (55,790 tons)	125,265 tons* > 111,568,236 lbs.	20 tons > 12,308 lbs.	411,033*

State of Idaho.

Year.	Production of Zinc (Spelter).	Concentrates.	Crude ore.	Total tonnage of ore treated.
1910	5,603,114 lbs. (2,802 tons)	> 5,526,717 lbs.	> 76,397 lbs.	34,006
1911	8,340,249 lbs. (4,170 tons)	12,198 tons > 8,289,877 lbs.	91 tons* > 50,372 lbs.	448,404*
1912	13,905,502 lbs. (6,953 tons)	54,381 tons* > 13,350,932 lbs.	736 tons > 554,570 lbs.	481,362*
1913	23,173,953 lbs. (11,587 tons)	30,311 tons > 20,915,197 lbs.	2,867 tons > 2,258,756 lbs.	649,058*
1914	42,012,435 lbs. (21,006 tons) (81% from Coeur d'Alene).	46,024* tons> 34,926,439 lbs.	8,730 tons* > 7,085,996 lbs.	676,903*

* Includes lead-zinc concentrates
Symbol > = produced

TARIFF CONDITIONS.

The existing tariff conditions, so far as they relate to zinc ores, exercise a certain amount of influence on the traffic in these ores.

Ores for Export. Prior to the war zinc ores were admitted, duty free, to all the countries of Europe which imported these ores. The European market, however, never has been of importance to the Canadian producer.

The United States, which has always been the market for raw zinc ores from Canada, levies import duties. At present zinc bearing ores are dutiable at the rate of *10 per centum ad valorem* upon the zinc contained therein, under paragraph 162 of the Tariff Act of October 3rd, 1913. Zinc ores are appraised under paragraph L, Section III, of the Tariff Act. The sections of the United States tariff of interest to the Canadian exporter of zinc ores read as follows:—

Paragraph 162. Zinc-bearing ores of all kinds, including calamine, 10 per centum ad valorem upon the zinc contained therein: *Provided*, That on all importations of zinc-bearing ores the duties shall be estimated at the port of entry, and a bond given in double the amount of such estimated duties for the transportation of the ores by common carriers bonded for the transportation of appraised or unappraised merchandise to properly equipped sampling or smelting establishments, whether designated as bonded warehouses or otherwise. On the

arrival of the ores at such establishments they shall be sampled according to commercial methods under the supervision of Government officers, who shall be stationed at such establishments, and who shall submit the samples thus obtained to a Government assayer, designated by the Secretary of the Treasury, who shall make a proper assay of the sample and report the result to the proper custom officers, and the import entries shall be liquidated thereon, except in case of ores that shall be removed to a bonded warehouse to be refined for exportation as provided by law. And the Secretary of the Treasury is authorized to make all necessary regulations to enforce the provisions of this paragraph.

Appraisement of Zinc Ore (T. D. 36446).

TO APPRAISERS OF MERCHANDISE AND OTHERS CONCERNED:

The following method will be followed by appraising officers in determining the value of zinc in imported ore arriving in the United States after July 1, 1916:

(1) From the ascertained assay deduct 8 units for sulphide and 6 units for nonsulphide ores. The remainder will represent percentage of recoverable zinc in the ore, which multiplied by 2,000 will give the number of pounds of zinc recoverable from a ton of ore.

(2) Multiply the result as above ascertained by the average price of prime western spelter at East St. Louis for the week in which the ore was exported; that is, the week including the date of sailing of the ship or day the car leaves the foreign country. This will give the gross value of the zinc in the ore at the time of its exportation.

(3) Deduct from the gross value of the zinc in the ore as above ascertained the following:

(a) The freight actually paid from the foreign mine to the domestic smelter receiving same in the United States.
(b) The insurance actually paid.
(c) The actual shipping charges.
(d) Foreign export duties and charges, if any.
(e) Treatment charge (as explained in par. 4).
(f) Penalties for iron, as stipulated in paragraph 5.
(g) Duty on lead contents, if any.
(h) Duty on zinc.

(4) *Treatment charge*—(a) For sulphide ores the treatment charge will be ascertained as follows: From the value of the recoverable spelter in a ton of 2,000 pounds medium grade Joplin sulphide ore, 60 per cent base, deduct the average of the quoted prices for such ore, and $1.50 per ton of 2,000 pounds as representing the average freight on Joplin ores from Joplin, Mo., to common Kansas smelting points.

(b) For nonsulphide ores the treatment charge will be ascertained as follows: From the value of the recoverable spelter in a ton of 2,000 pounds of 40 per cent calamine ore deduct the average of the quoted prices for such ore and $1.50 per ton of 2,000 pounds as representing the average freight paid from Joplin, Mo., to common Kansas smelting points.

(5) *Penalties.* On iron[1] ore deduct penalties as follows: $1 on each unit of iron in excess of 1 per cent up to and including 6 per cent; $0.50 per unit on each unit of iron in excess of 6 per cent up to and including 12 per cent; $0.25 for each unit of iron in excess of 12 per cent.

(6) The average market price of Joplin zinc ore and prime western spelter to be taken in accordance with quotations contained in the Engineering and Mining Journal for the calendar week, including the date of the sailing of the ship or day the car leaves the foreign country.

(7) Recoverable spelter, wherever that term is used in this memorandum, means for sulphide ores the assay minus eight units, and for nonsulphide ores the assay minus six units.

Example—**Sulphide ore.**

Assume: Assay 48 per cent zinc, 6 per cent lead, 14 per cent iron; freight, mine to smelter, $13 per ton of 2,000 pounds; insurance, $0.50 per ton; loading and expenses, $1 per ton; prime western spelter, 15 cents per pound; medium grade Joplin ore, 60 per cent base, $100 per ton.

48% − 8% = 40% × 2,000 lbs. = 800 lbs. at 15c			$120.00
Deductions:			
Freight, mine to smelter	13.00		
Insurance	.50		
Loading and expense	1.00	$14.50	

[1] This section should read "On the iron contained in the ore deduct, etc."

Penalties:				
$14\% - 1\% = 13\%$.				
5% at $1.00		$5.00		
6% at .50		3.00		
2% at .25		.50		
			8 50	
Treatment:				
$60\% - 8\% = 52\% \times 2{,}000 = 1{,}040$ at 15c		156 00		
Ore quotation	$100.00			
Freight to smelter	1.50			
		101·50		
			54·50	
Lead 2,000 lbs. $\times$ 6% = 120 lbs. at ¾c			.90	
				78·40
				$41.60

$41.60 ÷ $1.10 = $37.82 dutiable value.

Example—**Nonsulphide ore.**

Assume: Assay 36 per cent zinc, 3 per cent lead, 2 per cent iron; freight, mine to smelter $10 per ton of 2,000 pounds; export duty, $1; prime western spelter, 15 cents per pound; Joplin calamine, 40 per cent base, $50 per ton.

$36\% - 6\% = 30\% \times 2{,}000$ lbs. = 600 lbs. at 15c				$90.00
Deductions:				
Freight, mine to smelter		$10.00		
Export duty		1.00		
			$11 00	
Iron penalty, $2\% - 1\% = 1\%$ at $1.00			1 00	
Treatment:				
$40\% - 6\% = 34\% \times 2{,}000$ lbs. = 680 lbs. at 15c		102.00		
Ore quotation	$50.00			
Freight to smelter	1.50			
		51 50		
			50 50	
Lead duty (not over 3%, no duty)				
				62 50
				27 50

$27.50 ÷ $1.10 = $25 dutiable value.

Owing to the fact that the several factors necessary to determine the market value or purchase price of zinc ores are usually not known at the time of shipment, and importers can not ascertai[illegible] value of the zinc in the ore, collectors are authorized to permit entry by appraisen[illegible]-bearing ores.

(101088.) Andrew J. Peters, Assistant Secretary.

Smelting in Bond.—Zinc and lead ores may be imported into the United States and smelted and refined in bond under Subsection 1, Paragraph N, Section III, of the Tariff Act of October 3, 1913, and the regulations thereunder. The sections of the Act of interest to Canadian producers are as follows:—

N. Subsection 1. That the works of manufacturers engaged in smelting or refining, or both, of ores and crude metals, may, upon the giving of satisfactory bonds be designated as bonded smelting warehouses. Ores or crude metals may be removed from the vessel or other vehicle in which impor[illegible]r from a bonded warehouse, into a bonded smelting warehouse without the paymen[illegible] duties thereon and there smelted or refined, or both, together with ores or crude metals of home or foreign production: *Provided*, That the bonds shall be charged with the amount of duties payable upon such ores and crude metals at the time of their importation, and the several charges against such bonds may be canceled upon the exportation or delivery to a bonded manufacturing warehouse established under paragraph M of this section of an amount of the same kind of metal equal to the actual amount of dutiable metal producible from the smelting or refining, or both, of such ores or crude metals as determined from time to time by the Secretary of the Treasury. ***And provided further***, That the said metals so producible, or any portion thereof, may be

withdrawn for domestic consumption, or transferred to a bonded customs warehouse, and withdrawn therefrom, and the several charges against the bonds canceled upon the payment of the duties chargeable against an equivalent amount of ores or crude metals from which said metal would be producible in their condition as imported: *And provided further*, That on the arrival of the ores and crude metals at such establishments they shall be sampled and assayed according to commercial methods under the supervision of Government officers, to be appointed by the Secretary of the Treasury and at the expense of the manufacturer: *Provided further*, That antimonial lead produced in said establishments may be withdrawn for consumption upon the payment of the duties chargeable against it as type metal under existing law and the charges against the bonds canceled in a similar sum: *Provided further*, That all labor performed and services rendered pursuant to this section shall be under the supervision of an officer of the customs, to be appointed by the Secretary of the Treasury, and at the expense of the manufacturer: *Provided further*, That all regulations for the carrying out of this section shall be prescribed by the Secretary of the Treasury."

Customs Regulations, 1908.

SMELTING AND REFINING WAREHOUSES.

Art. 539. ***Application.*** Application for the establishment of a warehouse for smelting and refining imported ores and crude metals in bond, to be known as warehouse of class 7, must be made by the manufacturer or owner, through the collector or other chief officer of the customs at the port where the smelting or refining works are situated, giving the location of the premises and setting forth the work proposed to be carried on therein. The same procedure shall be had as required for bonding a warehouse of class 2. The penalty of the bond shall be fixed by the Secretary of the Treasury.

Art. 542. *Entry for Warehouse.* Upon the arrival of ores or of metals in any crude form from a foreign port at any port where such smelting or refining warehouse is situated, for the purpose of being smelted or refined in bond, or both, the same shall be entered for warehousing. The warehouse entry and bond having been executed, the collector will issue a permit to the inspector to send such ores or metals from the importing vessel or other vehicle, by designated bonded carts, drays, or lighters, to the smelting and refining warehouse named in the entry.

Art. 546. *Materials.* The storekeeper in charge of such warehouse will permit manufacturers to transfer thereto all necessary casks, barrels, or other packages required in which the smelted or refined metal or metals are to be packed for shipment.

Art. 552. *Renewal of Bond.* The proprietor of a bonded warehouse of this class shall, on ten days' notice from the collector, be required to renew his bond; and if he fail to do so, no further permits shall be granted for removal or transfer of ores or crude metals to such warehouse, which may be discontinued at any time by direction of the Secretary of the Treasury, when the safety of the revenue and the public interest may so require.

Art. 553. *Discontinuance.* The aforesaid proprietor shall have the right to relinquish the business at any time on application to the collector, with the consent of the Secretary of the Treasury, and on compliance with his directions in respect to such articles and merchandise as may be found remaining in the warehouse.

(T. D. 35216).

BONDED SMELTING AND REFINING WAREHOUSES.

Establishment of bonded smelting and refining warehouses under subsection 1 of paragraph N, of section 4, tariff act of October 3, 1913.

Treasury Department, March 10, 1915.

"To collectors of customs and others concerned:

The following regulations are hereby prescribed to govern the smelting or refining, or both, of ores and crude metals under subsection 1 of paragraph N of section 4 of the tariff act of October 3, 1913:

(1) Articles 539, 542, 546, 552, and 553 of the Customs Regulations of 1908, relating to applications for the establishment of smelting and refining warehouses, entry for warehouse, materials, renewal of bond and discontinuance, and article 554 of the said regulations providing for forms, except as it pertains to the form of bond for establishing a smelting and refining warehouse, are hereby extended to cover smelting and refining, or both, of ores and crude metals under subsection 1 of paragraph N of section 4 of the tariff act of October 3, 1913.

(2) Bonded ores or metals shall, until after the same have been sampled and weighed, be kept separate and distinct from nonbonded material.

(3) Upon receipt of the ores or crude metals in the bonded warehouse, the appraiser or officer assigned to that duty shall obtain proper and adequate samples from those taken for commercial purposes in the manner approved and practised by miners and others in the handling and reduction of ores and metals. This shall be done in the case of ores by thoroughly mixing and quartering portions of the importations, repeating the operation until the usual commercial sample is obtained.

In the case of crude metals or bullion one bar in ten from an importation shall be set aside for sampling; five bars from those so selected shall be laid side by side and punched, one punching being taken from each bar, beginning at the end of one outside bar and going diagonally across to the opposite end of the fifth bar, and the bars shall then be turned over and this punching repeated, likewise going diagonally across the bars, starting from the opposite corner, so that the punchings will be taken from a different part of the bar, ten punchings thus being obtained from the five bars. The punchings so obtained from the various sets of five bars shall be melted and run into a square bar, which bar shall then be sawed halfway through in a number of places from one side and the bar then turned and sawed from the opposite side in a similar manner; and the metal sawdust resulting shall constitute the sample for assaying.

The samples taken by the appraiser, or officer assigned to that duty, shall be delivered to the Government chemist, who will assay the same to determine the dutiable contents. The assay to be made shall be the wet assay, without deduction. If the importations at any smelting or refining warehouse are sufficient to justify it, and the proprietors make application therefor, a Government chemist will be stationed at such warehouse at the expense of the manufacturer.

Allowances shall be made for moisture in the imported ores, and such allowance shall be determined by the storekeeper or the Government chemist when present at the plant, the assay sample of the ore being weighed in the condition as imported pulverized fine enough to run through an 80 or 100 mesh sieve, then dried out by heat and reweighed, the difference between the two weights representing the moisture. From this result, by comparison with the first weight of the sample, the percentage of moisture shall be computed. The dried out sample shall be the sample delivered to the Government chemist for assay. Where there is no Government chemist located at the plant, samples of the imported ores in the condition in which the ores are at the time of weighing shall be forwarded, in hermetically sealed packages, to the Government chemist from time to time and shall be tested by him for moisture determination as a check against the allowance made for moisture.

"SMELTING AND REFINING OF LEAD

(4) The allowance to be made for wastage in smelting and refining of imported lead ores and bullion will be ascertained and fixed by the Secretary of the Treasury for each smelting warehouse, and for each refining warehouse, and for each combined smelting and refining warehouse bonded under the said subsection 1. An amount of lead equal to the lead contained in the imported ore or crude metal as ascertained by Government assay, less the wastage allowance, shall constitute the quantity of lead which must be either exported, transferred to a bonded manufacturing warehouse or bonded customs warehouse, or withdrawn for consumption, in order to secure the cancellation of the charge made against the bond. However, upon the withdrawal for consumption of lead smelted or refined under the provisions of said subsection 1, duty shall be collected upon the dutiable content of the quantity of ores or crude metals in their condition as imported from which said lead was produced and without allowance for wastage or for zinc entirely lost in the smelting or refining, or both, except as allowed in appraisement on importation (T. D. 34280, article 3). An assay shall be made of metals which are to be withdrawn for consumption, exportation, or transfer to a bonded manufacturing warehouse or bonded customs warehouse, with the exception of refined lead, which shall only be assayed from time to time at the discretion of the chief officer of customs in charge.

Antimonial lead produced in bonded smelting and refining warehouse may be withdrawn for consumption upon the payment of the duties charged against it, as type metal, at 15 per cent ad valorem, and the charges against the bond cancelled in a similar sum. Upon the withdrawal of antimonial lead for domestic consumption, it shall be sampled by the Government by the taking of dip samples, one from each lot or charge, and the samples so taken shall be assayed by Government assay to determine the lead and antimonial contents. The producers shall furnish, as soon as possible after withdrawal, to the United States appraiser at the port of withdrawal, in case of sale, a sworn statement of such sale showing: (1) The date of the sale (2) the contract number or other symbol by which the sale may be located on their books, (3) the quantity of antimonial lead, and (4) the actual selling price per pound, noting all discounts and trade allowances. The antimonial lead

withdrawn for consumption shall be appraised by the appraiser on withdrawal to determine its value at the time of withdrawal. If the appraiser shall be unable to ascertain and report the wholesale prices or market value by reason of the fact that antimonial lead of such character is not actually sold or offered for sale in the usual wholesale quantities in the principal markets of the country of origin of the importation covered by the bond to which the antimonial lead is credited, he shall ascertain and report the value thereof in the manner prescribed by paragraph L of section 3 of the tariff act of October 3, 1913. The value determined by the appraiser shall be the basis for the payment of duty. The bond shall be credited against the imported metals charged thereon, with the lead contents of the antimonial lead, determined by the Government assay of the dip samples, as above provided, plus the wastage allowance, together with any dutiable zinc entirely lost in the smelting or refining, or both, and there shall be credited to the duties charged against the bond an amount, in addition to that paid on the antimonial lead, sufficient to make the total credit equal the duties assessed against the lead so determined by assay, plus the wastage allowance and the dutiable zinc, if any, entirely lost in smelting or refining, or both, thus balancing the bond.

(5) *Proprietors' statements.*—Manufacturers engaged in smelting or refining, or both, under said subsection 1, shall immediately notify the Secretary of the Treasury of any material change in the character of the ore or base bullion smelted or refined, or both, and of any change in the methods of smelting or refining, and shall file with the Secretary of the Treasury an annual statement showing, among other things, the quantities of ore and bullion on hand at the beginning of the period covered by the statement and the lead contents thereof; quantities of ore or bullion received during that period and the lead contents thereof; total ore and bullion to be accounted for and the lead contents thereof; quantities of ore and bullion on hand at the end of the period and the lead contents thereof; quantities of ore and base bullion worked during the period and the lead contents thereof; intermediary products on hand at the beginning and end of the period and the lead contents thereof; net gain or loss in intermediary products as a result at the end of the period and the lead contents thereof; net quantities of ore and base bullion worked during the period and the lead contents thereof, to be accounted for in metals or wastage; quantities and kinds of metal produced in the plant on hand at the end of the period and the lead contents thereof; quantities and kinds of metal shipped during the period and the lead contents thereof; quantities and kinds of metal produced in the plant on hand at the beginning of the period and the lead contents thereof; total quantities of metals produced during the period and the lead contents thereof; and the wastage. If there is a gain in the intermediary products the amount should be subtracted from the total ore and base bullion. If there is a loss, the amount should be added to the total ore and base bullion. Complete smelting and refining records shall be kept from which said annual statement shall be prepared.

(6) *Withdrawal for direct exportation.*—For a direct exportation of the smelted or refined lead from a seaboard or frontier port there shall be filed an export entry with the collector of customs, who will issue a permit for exportation. Upon receipt of the permit the storekeeper in charge will deliver the lead therein described and make due return to the collector of customs and upon receipt of the lading inspector's return and a proper bill of lading, the collector will credit the warehouse bond with an amount equal to the quantity of lead so exported, plus the refining wastage allowance prescribed for the particular establishment from which withdrawal is made, computed upon the lead contents of the bullion refined, together with the lead if any, lost in the smelting process and the dutiable zinc entirely lost in the smelting or refining, or both.

(7) *Exportation from another port.*—For the exportation of such lead via some other port in the United States, there shall be filed with the collector of customs where the bonded establishment is located a transportation and exportation entry in triplicate, whereupon an export bond shall be executed in a penal sum equal to double the duties. The entry having been filed, a permit shall be issued by the collector to the storekeeper for delivery of the lead so withdrawn. An inspector will be designated to examine the packages, and if they accord in all particulars with the descriptions in the entry he shall make return accordingly on one of the copies of such entry. Such lead will thereupon be forwarded for exportation and will be exported in the same manner as merchandise under entry for transportation and exportation.

(8) *Withdrawal for transfer to bonded customs warehouse or bonded manufacturing warehouse at the same port.*—Upon receipt of an application for transfer of the lead to bonded customs warehouse or bonded manufacturing warehouse at the same port, the collector of customs will issue an order to the storekeeper to deliver the lead therein described to the surveyor to be transferred under the supervision of an inspector by bonded carts, drays, or lighters to the warehouse named, and will also issue an order to the storekeeper in charge of the receiving warehouse to receive such lead therein. The storekeeper at the receiving warehouse will compare the packages of lead received by him with the

withdrawal entry and make due return thereof to the collector, who will credit the warehouse bond of the establishment from which the lead is transferred, as provided in the case of withdrawal for transportation, exportation, or consumption. Such transfers will be at the risk and expense of the applicant, and the regulations governing the transfer of bonded merchandise from one warehouse to another in the same district, and the transfer of imported materials from bonded warehouse to bonded manufacturing warehouse will be followed so far as practicable. Where the transfer is to a bonded customs warehouse a bond will be required on Cat. No. 3577, and if the transfer is to a bonded manufacturing warehouse manufacturer's transfer bond (Cat. No. 3911), will be required. On the transfer of the lead to a bonded customs warehouse the duties shall be continued at the full amount charged on the imported ores or crude metals, that is, on a quantity of lead of the same kind as imported equal to the quantity of lead transferred, plus the wastage, together with any dutiable zinc entirely lost in the smelting or refining, or both; but on the transfer of the lead to a bonded manufacturing warehouse the duties shall be carried forward in rewarehousing computed only on a quantity of lead of the same kind as imported equal to the quantity of lead transferred.

(9) *Withdrawal for transportation to bonded customs warehouse or bonded manufacturing warehouse at another port.*—The same procedure will be followed as upon the withdrawal of merchandise from warehouse for transportation in bond. Upon arrival of the lead at the port of destination the same will be entered for rewarehouse and a certificate therefor will be forwarded to the collector of customs at the port of withdrawal, who will on receipt thereof cancel the transportation bond covering such withdrawal. The usual warehouse bond (Cat. No. 3577) will be required where the transfer is to a bonded customs warehouse, and where the transfer is made to a bonded manufacturing warehouse, manufacturer's transfer bond (Cat. No. 3911) will be required, and the duties shall be carried forward in each instance as provided in article 8.

(10) *Entry for warehouse and transportation.*—Upon the importation of ores or metals in a crude form at any seaboard port or frontier port of the United States consigned to a bonded smelting or refining warehouse situated at some other port of entry, the same may be entered for warehouse and transportation, waiving the usual appraisement and weighing, and entry made and the estimated duties based on the invoice weight or value of the lead contents when the goods may be forwarded in bond to port of destination.

(11) *Entry for rewarehouse.*—Upon entry of the merchandise for rewarehouse at the port of destination, samples shall be selected in the manner hereinbefore provided by the appraiser or officer assigned to that duty at the port where such smelting and refining warehouse is situated, after official ascertainment of weight, and samples assayed and report made.

(12) *Smelting and refining in separate establishments.*—In case the operation of smelting and refining is not carried on in the same establishment, the smelted and unrefined products or bullion obtained from the smelting of lead ores in a bonded smelting warehouse may be removed therefrom for shipment to a bonded refining warehouse located either at the same port or at another port. If the bonded refining warehouse is located at the same port, the procedure specified in article 8 for the transfer of the refined metal from the bonded smelting and refining warehouse to a bonded customs warehouse or bonded manufacturing warehouse will be followed. Where the transfer is to a bonded warehouse located at another port article 9 will be followed. In such cases the smelted and unrefined products or bullion obtained from the smelting of the imported lead ore and withdrawn shall be weighed, sampled, and assayed on withdrawal; and the bond of the smelting establishment will be credited with an amount equal to the lead content of the bullion as shown by the assay thereof, plus the wastage allowance for smelting prescribed for the particular smelter from which the withdrawal is made, together with the dutiable zinc entirely lost in the smelting. The withdrawal entry for transportation shall show the gross weight of the bullion withdrawn, the weight of the lead contained therein, the weight of the lead contained in the imported ore as above computed, that is, the weight of the lead contained in the bullion plus the wastage together with the dutiable zinc entirely lost in the smelting, and the duties for which credit is given based on the said amount of lead and zinc contained in the imported ore. The rewarehouse entry covering the metal at the bonded refining warehouse to which the bullion is transferred shall be made out in accordance with the withdrawal entry for transportation covering the bullion, both as to the respective weights and the duty, the duty being thus computed on the dutiable lead and zinc contents of the imported ore. Upon withdrawal of the refined lead from the bonded refining warehouse, the bond (Cat. No. 3577) of said refining warehouse charged with the dutiable lead and zinc contents of the ores at the time of original importation shall be credited with the refined lead so withdrawn, plus the wastage allowance for refining prescribed for said refining warehouse computed on the lead contents of the bullion, plus the smelting wastage allowance of the bonded smelting warehouse in which the bullion was

produced computed on the lead contents of the imported ore, together with any dutiable zinc entirely lost in refining or smelting, or both. However, when the refined lead is withdrawn for consumption, duty shall be collected on the dutiable lead and zinc contents of the imported ore from which the bullion was produced, no allowance for either smelting or refining wastage being permitted, nor for zinc entirely lost in the smelting or refining, or both, except as allowed in appraisement on importation. (T. D. 34280, art. 3.)

(13) *Withdrawal of lead refined in part from imported base bullion and bullion produced from imported ores.*—Upon withdrawal of lead from warehouse engaged in refining or both smelting and refining, part of which lead is obtained from imported base bullion and part from base bullion produced by smelting imported ores, the bond will be credited with the quantity of refined lead so withdrawn, plus (1) the wastage allowance for refining prescribed for that establishment, to be based upon the lead content of both the imported base bullion and that resulting from the smelting of imported ores used in producing the refined lead withdrawn, and (2) the wastage allowance prescribed for smelting for the establishment in which the imported ores were smelted, to be based on the lead content of the imported ores, together with the dutiable zinc entirely lost in the smelting or refining, or both.

(14) *Affidavits of proprietors as to dutiable zinc entirely lost.*—In the foregoing regulations where reference is made to the dutiable zinc entirely lost in the smelting or refining, or both, such allowance shall be made only upon affidavit of the proprietors furnished with their annual statement that no zinc was recovered.

SMELTING OF ZINC.

(15) The above regulations as applied to lead in ores shall also apply to importations of zinc in ores; but the allowance covering the zinc and lead lost in smelting zinc ores shall be the actual loss as shown by the sworn statement of the smelting company, which shall be an abstract from its smelter records, submitted to the collector quarterly, to be verified by the storekeeper. In case the zinc is withdrawn for consumption, duty shall likewise be paid on the entire dutiable content of the imported ores, that is, on the full dutiable zinc and lead content of the imported ores, without allowance for wastage, and without allowance for the lead entirely lost in smelting, except as allowed on importation where the imported ores contained lead in quantities of not more than 3 per cent.

RECOVERY OF BOTH LEAD AND ZINC.

(16) In case both lead and zinc are recovered in the smelting or refining process from the same ore or crude metals, separate account of the quantity of each metal so recovered shall be kept by the Government official in charge.

FORMS.

(17) The entries, permits, forms, and certificates required by these regulations will be those provided in article 554 of the Customs Regulations of 1908.

Ores for Import. The Canadian Tariff, at present in force, permits zinc ores to be imported into Canada free of duty under paragraph 329, "Ores of metals, n.o.p., Free." The tariff does not require detailed information with respect to the metallic contents of the ore. I am advised, by the Department of Customs, that if, at any time (on account of various ratings or otherwise) the Department needed detailed information as to the metallic contents that they would require that such information be shown on the invoice and upon the entry covering the importation. If, at any time, this information was considered as incorrect, "samples of the ore would be drawn and submitted to an expert for valuation of the different contents." In this connexion it may be noted that the Customs Act provides as follows:—

121. (1) Goods claimed to be exempt from duty under any Act relating to duties of Customs shall, in the entry thereof, be described and set forth in the words by which they are described to be free in the Act.

(2) If the goods do not answer such description, the collector or other proper officer may seize the same as forfeited, or, if the collector deems it expedient, he may detain the goods and report the case for the action of the Commissioner of Customs and the decision of the Minister as provided in this Act.

ELECTROLYTIC ZINC IN CANADA.

During the past year two plants to produce zinc by electrolytic processes have been planned and construction started.

In eastern Canada a plant was constructed to operate on the Watts process. A good deal of experimental work was done and a few tons of high grade spelter were produced. At present the plant is closed down and additional experimental work is in progress elsewhere.

In British Columbia the Consolidated Mining and Smelting Company of Canada have been building a plant, which, when completed, will be capable of producing 100 tons of spelter per day. At present the generator capacity installed is sufficient to produce 50 tons per day. The actual output, in July, was only about half this amount, but the output is being increased as rapidly as possible.

During the last five years the French process for producing zinc electrolytically has been undergoing development, and has been tried out at three points in British Columbia. It has recently been announced that arrangements have been made to erect a plant for treating custom ores in the vicinity of Nelson, B.C. The government of British Columbia is also credited with interesting itself in the matter to the extent of guaranteeing the interest on a bond issue of $40,000.

As to the cost of producing zinc by an electrolytic process little can be said at present. Electrolytic plants are in course of erection at a number of points in the United States as well as in Canada, and the total capital that is being invested in these plants is very large. Both the promoters and the operators are satisfied that the initial difficulties have been overcome, and that these plants can be operated at a profit under normal conditions. It is expected that the cost per pound for producing zinc, all charges included, will be between 4 and 4½ cents. It is doubtful if any producers have yet attained this figure. It has not yet been attained in Canada, but it appears feasible to attain it. In this connexion it must not be forgotten that the cost per pound of metal produced, charged to the zinc plant, must be in part controlled by the method of book-keeping adopted. The complex silver-lead-zinc ores, or copper-zinc-gold ores that can be utilized by this process, some of them of a quality or grade that could not be utilized economically by any of the other processes in use, also yield other valuable constituents. If the entire value of these constituents, after their recovery in marketable form, is credited to the zinc plant, it is probable that the actual cost of producing the zinc by an electrolytic process will be even less than that given above.

The possibility of producing zinc commercially by an electrolytic process has altered the whole situation in western Canada. Hydro-electric power in abundance is available at a cost relatively much cheaper than heat from other fuels. The long haul of low grade ores to a distant market can be abolished; only the finished products have to be moved

to market. It may prove that plants of relatively small capacity, when compared with an ordinary smelting plant, can be operated commercially. If so, certain isolated districts which are provided with abundant water power, may be able to become producers.

The zinc producers of the Kootenay district should have a special interest in the development going on at Trail, and the proposed plant at Nelson. The Consolidated Mining and Smelting Company of Canada own, in the Sullivan mine, one of the greatest lead-zinc mines that has been found in Canada up to the present time. This property has been very extensively developed and is capable of producing enough ore to operate the zinc plant at Trail.

The development of lead mining in the Kootenays during the last ten or more years has been in a large measure due to the operations of this Company. As soon as the numerous initial difficulties necessarily encountered in developing a new process are overcome, and the successful production of electrolytic zinc on a commercial scale has been started, it is the intention of the Company to handle zinc custom ores in about the same way as they now handle lead ores. In fact it must be obvious that this is the only course open to them, since the output of lead ores necessary to keep their lead plant in operation is so intimately associated with the output of zinc ores.

At the present time the Consolidated Company is not in the market to purchase zinc ores and no tariff for treating zinc ores has been announced. It is very doubtful if they will be in the market for zinc ores before the summer of 1917.

The French Complex Ore Reduction Company have only just announced that they propose to proceed with a plant at Nelson. This plant is primarily intended as a customs plant. It is not possible to predict when they will be ready to receive custom ores, but, owing to the conditions of the labour market, and the machinery and supply market, it may be safely assumed that they cannot get into a position to treat ores during the present year.

ESTIMATES ON THE COST OF SMELTING ZINC ORES IN CANADA.

The following estimates represent an attempt to determine the probable cost of smelting one ton of zinc concentrates in Canada in 1916. They are based on the estimates given in the Zinc Commission Report, 1906,[1] but the rates used are those given in the preceding pages of this report. For comparison similar estimates of the present cost of zinc smelting in the United States are also given.

[1] Pages 31 and 54. See also Mineral Industry, Vol. 16, 1907, p. 929.

1. Plant located in Crowsnest Pass area, using coal for fuel, modern producers, and importing St. Louis clay. Capital cost taken as $25.00 per annual ton of capacity and depreciation placed at 15%.

Labour, 2½ men for 1 day at $3.50	$8 75
Fuel, 2 tons coal at $2.00	4 00
Reducing material, ½ ton at $2.50	1 25
Retort clays, ⅛ ton at $10 00	1 25
Supplies	25
Repairs and renewals	1 20
Depreciation and interest	3 75
Administration	1 20
	$21 65

2. Plant located in Medicine Hat or Bow Island gas field, using natural gas for fuel for both the reduction furnaces and the roasters, and importing St. Louis clay. Capital cost taken as $12.00 per annual ton of capacity, and depreciation placed at 20%.

Labour, 2¼ men for 1 day at $3 50	$7 88
Fuel, 50,000 cu. ft. natural gas at .02	1 00
Reducing material, ½ ton at $3 50	1 75
Retort clays, 1/10 ton at $9 50	95
Supplies	25
Repairs and renewals	50
Depreciation and interest	2 40
Administration	1 10
	$15 83

3. A plant located in the Illinois field, using Illinois coal for fuel, anthracite screenings from Chicago for reduction purposes, and importing St. Louis clay. Capital cost taken as $16.00 per annual ton of capacity, and depreciation placed at 10%.

Labour, 2½ men for 1 day at $3 50	$8 75
Fuel, 2 tons coal at $1 80	3 60
Reducing material, ½ ton at $2 70	1 35
Retort clays, ⅛ ton at $3.75	47
Supplies	25
Repairs and renewals	85
Depreciation and interest	1 60
Administration	1 10
	$17 97

4. A plant located in Oklahoma natural gas field, using natural gas for fuel for both the reduction furnaces and the roasters, and importing St. Louis clay. Capital cost taken as $8.00 per annual ton of capacity, and depreciation placed at 20%.

Labour, 2¼ men for 1 day at $3 50	$7.88
Fuel, 50,000 cu. ft. natural gas at .03	1 50
Reducing material, ½ ton at $3 50	1.75
Retort clays, 1/10 ton at $4.50	.45
Supplies	.25
Repairs and renewals	50
Depreciation and interest	1 60
Administration	1.00
	$14.93

5. A plant located in the Crowsnest Pass area, using for fuel a coal product that is now partly wasted, modern producers, and using local Saskatchewan clays (assuming that they are suitable). Capital cost, under normal conditions, taken as $20.00 per annual ton of capacity and depreciation placed at 15%.

Labour, 2½ men for 1 day at $3 50	$8.75
Fuel, 2¼ tons coal, at $1 25	2 82
Reducing material, ½ ton at $2 00	1 00
Retort clays, ⅛ ton at $4 32	58
Supplies	25
Repairs and renewals	1.00
Depreciation and interest	3 00
Administration	1.10
	$18 50

ORE SALES AND CONTRACTS.

The subject of the valuation of zinc ores was discussed at length in the Report of the Zinc Commission,[1] and the methods by which these ores are valued and purchased are very clearly elucidated. This section of the Report of the Commission is reproduced here as an introduction to the section in which the terms of a number of recent and existing contracts for zinc ores are given.

The Valuation of Zinc Ores.

The value of a zinc ore depends chiefly upon its tenor in zinc and objectionable impurities; especially iron, manganese and lime, which increase the corrosion of the retorts; and lead, arsenic and antimony, which contaminate the spelter. The value of the ore is also affected by its character, whether oxidized or sulphide, or a mixture of both; the sulphide ore must be roasted, but yields a diminished weight for the subsequent treatment, which is the more expensive part of the process; the oxidized ore escapes preliminary treatment, unless it be carbonate, but suffers no diminution in weight. The preliminary treatment of ores which are mixtures of sulphides and oxides is often troublesome. The value of an ore is, moreover, affected by its physical character. Lump ore is subject to an additional expense for crushing; fine slimes are more expensive and troublesome to roast than coarser concentrates. Some ores roast and distil easily; others with more difficulty. All these factors are given consideration by the zinc smelter. The chemical composition of the ore is, however, the most important factor in determining its value.

In determining the treatment charge on the ore purchased, the smelter starts with the cost of smelting a ton of the ore of average composition, that is to say the mixture on which he proposes to operate his furnaces. It is aimed to have all the furnaces on the same charge, for various reasons. To this smelting charge he adds the profit that he ought to make to obtain a proper interest on his investment, allowing for the necessary amortization of his outlay in plant.

The further addition of the freight on the ore to his works, and on the spelter product to its market, with allowances for the cost of buying the ore and selling the spelter, gives the returning charge which he must make against the ore in buying it on the basis of f.o.b. cars at the mine or mill where produced.

The ores purchased will be of various kinds. Few will correspond exactly with the ore which it is aimed to charge into the furnaces. Some will be higher in zinc; others will be lower. Some will be too high in iron; others too high in lime. The very desirable ores can, perhaps, be purchased only at a small margin. The deficiency must then be made up from the price of the less desirable ore. Inasmuch as the various kinds of ore may not be bought contemporaneously, the smelter effects this balancing in price by arbitrary additions to the returning charge on certain kinds of ore according to the percentage of objectionable impurities contained. It may be necessary under certain contingencies to put a less ad-

[1] Pp. 22–28.

vantageous charge into his furnaces, when the cost of smelting will be directly increased and the percentage of metal extraction decreased, by greater destruction of retorts, higher zinc tenor of the residues, or some other factors which have a powerful influence on the ledger.

It is the custom of European smelters to pay for ores according to a sliding scale, which combines three elements, viz., the price of spelter and zinc content of the ore, which are variables, and the returning charge per ton of ore which is fixed. This sliding scale is embodied in a convenient formula, from which any seller of ore can readily compute the value, the returning charge having previously been agreed upon in the contract.

American smelters compute the value of ore in practically the same way, but in purchasing custom lots of ore they make usually a direct bid of so much per ton, and in purchasing ore on contract they frequently employ an involved sliding scale, which is generally equitable, though less simple than the European.

The smelters of Belgium, Holland, France, and the West of Germany employ generally the formula $0{\cdot}95\ P\left(\frac{T-8}{100}\right) - R$ in which P is the price of spelter (good, ordinary brands), at London, T the units of zinc in the ore, and R the returning charge per ton of 1,000 kg. This formula gives the value of the ore per ton of 1,000 kg. The value is given in pounds sterling, marks, francs, or dollars according as P, the value of spelter at London, is reckoned in pounds sterling, marks, francs or dollars.

This formula is scientific and fair. The freights and cost of smelting per ton of ore are substantially the same irrespective of the grade of the ore (within certain limits). The returning charge R is therefore constant, as it should be. The percentage of metal extracted falls off as the grade of the ore falls off, because the losses in smelting are to a large extent constants, *i.e.*, a ton of certain ore may contain 1,000 lb. of zinc and a ton of another ore 800 lb. of zinc, but the loss of metal in smelting will be approximately 125 lb. in each case. The formula takes account of this by the uniform deduction of eight units from the zinc content of the ore as shown by assay. If the ore assay 60 units of zinc, the payment is for 52 units, or 86⅔% of the zinc in the ore. An ore assaying 50 units, with eight units deduction, returns 84%; and an ore assaying 40 units, with eight units deduction, returns 80%. These percentages are not very much below the actual metallurgical extractions. In being a little under the actual extraction it tends to increase slightly the smelter's margin as the value of spelter rises, as does also the discount of 5% from the London price, but this is equitable.

Sometimes in the case of a desirable ore, the smelter will propose to buy the ore with a deduction of only seven units from the assay, instead of eight, as usual. The percentage of zinc paid for, on different grades of ore, becomes then as follows:

60 units: 88·33%
50 units: 86·00%
40 units: 82·50%

Sometimes, if it be anticipated that lower grades of ore than contemplated in the returning charge, named in the contract, will be offered, it is provided that the returning charge be increased with decrease in the grade of the ore. For example, it may be provided that for each unit of zinc below 50, the returning charge shall be raised 2·5 francs per 1,000 kg. of ore, which is equivalent to 43·86 cents per 2,000 lb. If therefore, the returning charge were named at \$11.50 per 2,000 lb. for ore assaying 50 to 55% zinc, with increase of 43·86 cents per unit below 50, the charge on ore assaying 48% zinc would be \$12.38 per 2,000 lb.

The formula $0{\cdot}95\ P\left(\frac{T-8}{100}\right) - R$ works out as follows in the case of an ore assaying 48% zinc, the London price of spelter being assumed at £28 per ton of 2,240 lb., and the returning charge £2 12s. 6d. per ton of ore.

$0{\cdot}95\ P = 0{\cdot}95 \times £28 = £26{\cdot}6.$

$\left(\frac{T-8}{100}\right) = 0{\cdot}48 - 0{\cdot}08 = 0{\cdot}40.$

R = £2 12s. 6d. = £2·625.

$£26{\cdot}6 \times 0{\cdot}40 - £2{\cdot}625 = £8{\cdot}015 = \$38.95.$

The value per 2,240 lb. of ore is \$38.95. Dividing that result by 1·12 gives the value per 2,000 lb. of ore, thus \$38.95 ÷ 1·12 = \$34.78.

The same result is obtained when the price of spelter and the returning charge are converted into terms of dollars and cents per 2,000 lb. Thus, £28 per 2,240 lb. × 6·075 cents per pound = \$121.50 per 2,000 lb.; 0·95% of this is \$115.43; the returning charge of £2 12s. 6d. per 2,240 lb. is equivalent to \$11.39 per 2,000 lb. The value of the ore per 2,000 lb. is consequently:

$\$115.43 \times 0{\cdot}40 - \$11.39 = \$34.78.$

Another method, which is very convenient, is to convert the expression T–8 into pounds and multiply by the price of spelter per pound. Thus, and

T–8 = 40; and 40 × 20 = 800 lbs.

0·95 (6·075 × 800) – $11.39 = $34.78.

The returning charges which have been made by European smelters on American, Australian and Canadian ores during the last two or three years have ranged from $11.40 to $13.16 per 2,000 lb., these figures corresponding to 53 at 60 marks or 65 at 75 francs per 1,000 kg.

The terms offered by European smelters include various provisions, which must be given consideration. The basis of settlement is always c.i.f. at some specified port, usually Antwerp. A percentage of the value of the consignment, say 75% or 80%, may be drawn upon remittance of the bill of lading; the remainder upon arrival of the consignment, and determination of its assay value. In connection with the latter, the zinc must be determined by the Schaffner method (sodium sulphide titration). Differences of one unit or less between the assays of the buyer and seller are split. Differences in excess of one unit are umpired. The umpire must be an European chemist (specified in the contract). His method is accepted as final if it fall between those of the buyer and seller. If it fall outside, the original assay which is nearest to the umpire's is taken. The party whose assay is furthest from the umpire's pays the expense of the latter. These conditions as to umpire assays are the same as obtain in the settlement for ores in Canada and the United States.

The price for spelter is the average for good ordinary brands at London, as reported by the *Public Ledger*, during the month of the arrival of the shipment. In the case of contracts covering the output of a year or more, it is sometimes provided that the settlement basis shall be the average price of spelter for the year. Provisional settlements are made on the monthly averages, but at the end of the year a final computation is made and the difference between it and the sum of the monthly settlements is debited or credited as required.

As previously remarked, the settlement for ores in Europe is based on the London price for spelter. In the United States it is based on the St. Louis price, or the New York price, there being generally a constant difference between the quotations at St. Louis and New York, corresponding to the difference between the freight rate from Kansas works to St. Louis, and to New York. This difference was formerly about 20 cents per 100 lb., now, and in recent years, it has been about 15 cents. In statistical investigations it is necessary to refer to the New York price, rather than to the St. Louis, because there are authoritative statistics going farther back. Contracts are commonly based on the quotations for spelter in the *Engineering and Mining Journal*.

The difference between settlement on the London and New York markets is a very important consideration to the Canadian exporter of zinc ore. The range of the two markets is shown in a table which is presented elsewhere in this report. It appears, therefrom, that although the London price has been at certain times in excess of the New York price, the average over a long series of years has been lower than the average at either New York or St. Louis. Whenever the London price has been higher, the United States has exported spelter, and this movement of metal has reduced the London price below the American level, or has forced the American price to rise above the European level. There is no shortage of ore supply available to European smelters. On the contrary not only the ore supply, but also the smelting capacity, are going to be immensely increased by the operations of strong companies owning enormous reserves of ore at Broken Hill, New South Wales, which are already developing their plans. So long therefore as the American Government maintains a duty on the importation of spelter, it is to be anticipated that the London price for spelter will continue to average a little lower, in the long run, than the American price.

The western smelters of the United States, in their ore contracts, employ sliding scales of the following character:

(1) Basis of settlement: Ore delivered at smelting points in Kansas. When spelter is at 6c per lb. at St. Louis, pay $25 per ton (2,000 lb.) for ore containing 47% zinc, plus 75c per unit for zinc in excess of 47 units, less 75c per unit for zinc below 47 units; with 35% of the variation in spelter.

(2) Basis of settlement: Ore delivered f.o.b. car at mines. When spelter is at 6c per lb. at St. Louis, pay $24.50 per ton (2,000 lb.) for ore containing 53% zinc, plus $1 per unit for zinc in excess of 53 units, less $1 per unit for zinc below 53 units; with 42·5% of the variation in spelter.

The above were the terms of contracts for Canadian ores in effect during 1905.

The inferiority of a contract so expressed, in so far as a clear understanding is concerned, in comparison with the European contracts is quite obvious. Taking the latter of the two for example, the meaning is that when spelter is worth 6c per lb. at St. Louis, ore assaying 53% zinc is worth $24.50 f.o.b. mine. Ore assaying 54% zinc is worth $25.50; ore assaying 52% zinc is worth $23.50. A variation in the price of spelter changes the basis price to the

extent of 42½% of the variation per ton of spelter, *i.e.*, if the price for spelter be 5·7c per lb. at St. Louis, a reduction of 0·3c per lb. = ($6 per ton) from 6c., or $6 × 0·425 = $2 55, is made from the basis price of the ore, wherefore the value of ore containing 53% zinc becomes $24.50 − $2 55 = $21.95. Ore with 54% zinc is then worth $22.95; ore with 52% zinc is worth $20.95.

The equity of such a contract can be determined by a consideration of its operation under different conditions. Converting $24.50: 6c : 53% zinc into an expression of $P\left(\frac{T-8}{100}\right) - R$, it appears that R = $29.50, this including all freights, smelting charges, profits, etc. Tabulating the results for different grades of ore computed by $P\left(\frac{T-8}{100}\right)$ − $29.50 in the column B, and the results computed according to the sliding scale of the contract under the column A, the comparison appears as follows when spelter is at 6c per lb. St. Louis:

% Zinc in Ore.	A	B
45	$16.50	$14.90
50	21.50	20.90
55	26.50	26.90
60	31.50	32.90

When spelter is at 5c St. Louis, the comparison becomes as follows:

% Zinc in Ore.	A	B
45	$ 8.00	$ 7.50
50	13.00	12.50
55	18.00	17.50
60	23.00	22.50

If spelter should rise to 7c the comparison would be as follows:

% Zinc in Ore.	A	B
45	$25.00	$22.30
50	30.00	29.30
55	35.00	36.30
60	40.00	43.30

Aside from the question of the returning charge there is nothing in this sliding scale which is unfavourable to the miner. At 5c. for spelter the price received for ore of different grades is approximately the same in each case as the St. Louis value of the spelter extractable from the ores less a uniform returning charge. At 6c for spelter the margin to the smelter diminishes with decrease in the grade of the ore below 53%; with increase above 53% the margin would increase; these conditions would be emphasized if the price of spelter should attain 7c. In the particular contract the ore was likely to run a little under 53% rather than over it, wherefore less risk was taken by the miner than by the smelter upon fluctuations in the grade of the ore and in the market for spelter.

A comparison between the terms offered by American and European smelters may be made in the case of this ore. With spelter at 6c, St. Louis, the American smelter paid $24.50 per 2,000 lb. f.o.b. mine for ore containing 53% zinc. The European smelter would pay $39.64 c.i.f. Antwerp. Deducting the freight to Antwerp, $13 per 2,000 lb., and an allowance of $1 for incidentals and loss, as previously discussed, the price f.o.b. mine would be $25.64. However, at the time of the contract the London price for spelter was considerably lower than the New York price, wherefore the American price figured out the better.

The average price of spelter at St. Louis was 5·730c; at London, 5·518c. On these prices the value of the ore taken as an example would have been $22.20 per 2,000 lb. f.o.b. mine under the American contract and $21.50 under the European contract.

It will appear from what has previously been said, together with the data as to cost of smelting, etc., which will be found in a subsequent section of this report, that as between the American and European smelters, previous to the recent Treasury decision, the former were in a position to command the market for zinc ore in British Columbia if they chose. The price that they would offer for ores was limited by the best terms which European smelters could make, but otherwise was governed by competition among themselves, their requirements for ore, and to a large extent by the condition of the Joplin ore market, which is still their most important source of supply, although since 1901 its relative importance has been diminishing, and probably will continue to do so. However, the Joplin district will doubtless continue to have a dominating influence on the general ore market for a long while to come, and its prices will to a large extent be used as a basis. It is rather important to consider how prices for other ore work out on this basis.

The average price of ore at Joplin over a long period of years is given in another section of this report. The average for 1905 was $47.40 per 2,000 lb. in the bins of the mines. Assuming an average cost of 40c per ton for carting and loading the ore on board cars, the cost per ton delivered at Kansas smelting points would be about $48.75. This is for ore assaying 60% zinc, and low in iron, say not more than 2%. An old rule of the district is to deduct $1 per unit of zinc under 60 and $1 per unit of iron over 2. The ore that has previously been taken as an example contains about 7% iron. The value of such an ore delivered at the smelting works on the Joplin basis would be therefore $48.75 − $12 = $36.75 on the basis of 5·73c for spelter at St. Louis. Reckoning $10 railway freight from the Slocan, 20c freight on moisture, 30c loss in handling, 30c duty on lead contents and 20c for incidentals, the value of $36.75 per ton delivered at smelting works would correspond to $25.75 f.o.b. mine, against the value of $22.20 according to the terms of the contract.

This difference is not on the face unfair, inasmuch as the computation is based on a price of $47.40 for ore assaying 60% zinc at Joplin, but that price leaves only a small margin to the smelter, in fact, scarcely a living margin, when spelter is at 5·73c St. Louis. The deduction of $1 per unit for iron in excess of two units, however, is, too much, being more than the increased cost of smelting such an ore, and the smelter could have afforded to have paid a better price than $22.20 for the ore and would have done so if he had been compelled thereto by competition.

Ore Contracts.

In the Joplin district, Missouri, zinc ores are almost invariably sold on the ground in lots which vary from a few tons up to several thousand. Zinc ores from the Cordilleran region and from other outlying points in America are usually sold on contract. These contracts call for the delivery of a definite tonnage of ore of a certain grade within a specified time. It is only very rarely that the entire output of a mine, without limitations as to tonnage, is placed under contract, and the larger producing mines are often selling ore under several different contracts at the same time. The market quotations of spelter at East St. Louis, as reported by the *Engineering and Mining Journal* of New York, almost invariably constitute the basis of settlement for both United States and Canadian zinc ore contracts. Where the ores contain silver, the basis of settlement is usually the New York market quotation as published by this same journal. Gold, when present, is usually paid for at a flat rate for all above a specified minimum.

Three general types of western ore contracts may be recognized:—

a. The ore must contain (within fixed limits) a certain percentage of zinc whose value will be based on the price of spelter at East St. Louis, and 85 per cent of the metallic content will be paid for at this price, with certain deductions for treatment, depending on the spelter market. The

working charge will be stated ($13 to $15) on the basis of, say, 5 cent spelter, and provision will be made for a variation up or down of so many dollars per ton for each rise or fall of one cent in the price of spelter.

b. A flat price will be agreed upon for a certain percentage grade of ore, f.o.b. smelter, with a base price for spelter at East St. Louis. Variations will be paid for on a basis of a certain percentage (70%-75%) of the market variation, and with a variation of so much per unit for the metallic content above or below the unit grade, within certain prescribed limits downward.

c. A flat price will be agreed upon for a certain percentage grade of ore f.o.b. smelter with [illegible] market variation of a fixed amount per ton as the price of spelter goes u[illegible]n. Variations in the metal content o[illegible] ore above or below the [illegible]ade are adjusted by adding or subtracting a fixed amount per unit va[illegible] All precious metals are paid for beyond certain limiting unit quantities.

In nearly all contracts provision is made for their cancellation by the buyer if the shipper fails to make deliveries within a certain specified time; or the contract may be extended beyond the original limits for an equivalent period, at the option of the buyer. Many of the contracts with Canadian ore producers contain a clause providing for their temporary or permanent suspension if either the Canadian c the United States government takes any action which will directly or indirectly interfere with the terms of the contract, or make it unprofitable.

The weight of the ore for valuation purposes, or for determining freights, is always the dry weight, and the unit of weight in America is the ton of 2,000 pounds. Where settlement is to be made for variations in either the metal content above or below the prescribed percentage, or for variations in the market quotation of spelter, fractional parts are always reckoned proportionally.

Provision is often made for a preliminary settlement, payment being made for a certain percentage of each shipment, on presentation of the bill of lading, with assay certificate attached. These settlements usually vary between 70 and 80 per cent of the estimated value of the ore. Final settlements may be made on the basis of the average weekly price of spelter according to the *Engineering and Mining Journal* quotations, are occasionally made on the average monthly prices, and, in at least one contract known to the writer, are made on the average yearly price, this latter being determined by dividing the sum of the total monthly averages by twelve.

The following paragraphs show in summary form the terms of a number of zinc contracts for the purchase and sale of zinc ores from mines in British Columbia, Idaho, and Montana. It will be noted that there is great variation in the terms of the contracts, in fact no two of them are exactly alike. It will also be noted that the more recent contracts are much less

favourable to the miner than were the contracts in force prior to the beginning of the European war.

All of these contracts call for the delivery of a definite tonnage of ore per month for the duration of the contract. The period of time that the contracts noted as operative in 1916 have to run, so far as British Columbia mines are concerned, varies from one to four years. The contracts are not arranged in any definite order, except that the older contracts proceed. It has been considered best to designate them by number only, and to withhold the names of the producing mines. It should be noted, however, that contracts numbers 21, 22, and 23 relate to carbonate and silicate ores, and contracts numbers 4, 5, 9, 10, 15, 16, 17, 18, 19, 20, and 24 relate to zinc ores with little or no silver content. The remaining contracts relate to zinc concentrates produced from typical lead-zinc-silver ores as mined in British Columbia and the Coeur d'Alene. It should also be noted that one cause for the variation in the nature of the contracts is the special character of the ores produced by the individual mines selling under any specified contract. There is a very considerable variation in the character of the ores sold, and the contractors naturally take this into consideration when negotiating for ore purchases, and vary their terms accordingly.

1. Operative 1914, base price $20.70, London quotation £26 10s.[1] for a 45% zinc product; variation above or below 45% add or deduct $1.00 per unit; market variation of 1 cent per pound, add or deduct $7.00 per ton from the base price. Silver paid for at 75% of New York quotations, less six ounces. An allowance of $1.60 per ton made for sacking the ore.

2. Operative 1915, base price $34.50 for a 45% zinc product containing 30 ounces of silver; variation above or below 45% zinc add or deduct $1.00 per unit; for each ounce of silver above or below 30 ounces add or deduct 30 cents per ounce.

3. Operative prior to 1915, base price $20.00 for a 45% zinc product; variation for zinc content $1.00 per unit up or down; market variation $6.00 per ton for every cent increase above 5 cents. Silver paid for at [illegible]% of the New York market, after deducting six ounces. Penalty for lime above 2% was $1.00 per unit, but there was no lead penalty.

4. Operative 1915, base price $18.25 for a 50% zinc product when market is at 5 cents; variation $0·625 per unit for each unit; market variation $6.00 per ton for each cent rise or fall in the quotation from 5 cents.

5. Operative 1915, base price $21.50 for a 45% zinc product on a 5 cent market; variation above or below 45% on a 5 cent market add or deduct $1.00 per unit; market variation add or deduct $7.00 per ton for each cent rise or fall in the quotation from 5 cents to a maximum price of 8 cents, no increase above 8 cents. Silver paid for at 65% of the New York market after deducting a treatment charge of $3.00 per ton.

[1] This contract is unusual in that, apparently, London quotations are used as a base price without establishing the St. Louis equivalent quotation, while variations are in a decimal currency.

6. Operative prior to 1916, base price $22.50 in a 5·5 cent market for a 40% zinc product; unit variation $1.00 up or down; market variation $5.00 per ton for each rise or fall in spelter market. Ore below 38% not accepted.

7. Operative prior to 1916, base price $21.50 for a 45% zinc product on a 5 cent market; variation above or below 45% on a 5 cent market add or deduct $1.00 per unit; market variation $6.00 per ton for each cent over base price, with no upward limit. Silver was paid for on the basis of 75% of the New York market after deducting six ounces.

8. Operative 1916, base price $57.00 for a 40% zinc product containing 45 ounces of silver, not over 10% iron and 2% lime; variation above or below 40%, add or deduct $1.00 per unit. For each ounce of silver above or below 45 ounces add or deduct 40 cents per ounce. All gold above 0·05 ounces paid for at $19.00 per ounce. Minimum zinc content accepted is 35%.

9. Operative 1916, base price $17.00 for a 40% zinc product; variation for zinc content $1.00 per unit up or down; market variation $3.00 per ton for every cent increase between 5 and 8 cents inclusive, $2.50 per ton between 8 and 12 cents inclusive, $2.00 per ton between 12 and 14 cents inclusive, the latter being the top price. Silver is paid for at 60% of the New York market, and a residue treatment charge of $4.50 is levied.

10. Operative 1916, base price $42.50 for a 40% zinc product; variation $1.50 up for each unit in excess, and $1.00 down for each unit below 40%. Allowed 15% iron, 3% lead, and 3·5% combined lime and magnesia; above these penalized at rate of $1.00 per unit. When lime falls below 2·5% are paid a premium of $1.50 per unit for each per cent below this limit, fractions proportionally. When lime is less than 2%, 50 cents per unit is added to the zinc rate for each unit in excess of 40%.

11. Operative 1916, base price $44.00 for a 35% zinc product containing 25 ounces of silver, and not over 12% iron and 1% lime; variation $2.00 per unit for each unit above or below the base, no ore accepted below 33% zinc. Silver variation above or below 25 ounces is 40 cents per ounce, with no allowance for silver in ore containing less than 10 ounces. Lime penalty $2.00 per unit for excess above 2% and iron at $1.00 per unit above 12%.

12. Operative 1916, base price $17.00 for a 40% zinc product on a 5 cent market; variation above or below 40% add or deduct $4.00 per unit; market variation of 1 cent per pound between 5 and 6 cents add $4.00 per ton, between 6 and 14 cents add $3.00 per ton, no payment for increases above 14 cents. Silver paid for at 95% of the New York price for 60% of the content, after deducting a residue treatment charge of $4.00 per ton. No payment made for less than 12 ounces, lime penalized at $2.00 per unit above 2%, 8% lead allowed but not paid for, 12% iron allowed.

13. Operative 1916, base price $45.00 for a 50% zinc product containing 60 ounces of silver with spelter quoted at 5 cents; variation above or below 50% add or deduct $1.00 per unit; market variation of 1 cent per pound below 5 cents deduct $7.00 per ton, above 5 to 6 cents add $7 per ton, from 6 to 8 cents inclusive add $5.00 per ton, from 8 to 10 cents add $3.00 per ton, from 10 to 11 cents add $1.50 per ton, from 11 to 12 cents add $1.00 per ton, no variation above 12 cents. If quotation is in excess of 8 cents preliminary settlement is made on an 8 cent basis. Variation in silver content, above or below 60 ounces, to be added or deducted on basis of 40 cents per ounce. Ores to be free from arsenic, iron, tin, and bismuth, not to contain over 3·5% oxides of lime and magnesia, with penalty for lime in excess of 2% at $1.00 per unit.

14. Operative 1916, base price $54.00 for a 35% zinc product; variation above or below 35% add or deduct $2.50 per unit to a minimum of 28%

15. Operative 1916, base price $58.00 for a 48% zinc product or over, when spelter is quoted at 13 cents or above; variation $5.00 per ton down to 11 cents, $3.00 from 11 to 7 cents, $5.00 per ton below 7 cents.

16. Operative 1916, base price $58.00 for a 48% zinc product, with a unit variation of $1.75 for ore down to 45%, and $2.00 per unit down to 40%, this latter being the minimum that will be accepted.

17. Operative 1916, base price $63.00 for a 50% zinc product, with a unit variation of $1.75 for ore down to 45%, and $2.00 below 45%.

18. Operative 1916, base price $58.00 for a 50% zinc product, with a unit variation of $1.50 for ore down to 45%.

19. Operative 1916, base price $43.00 for a 40% zinc product, with a unit variation of $1.00 per ton for ore above, and $1.50 per ton for ore below 40%.

20. Operative 1916, base price $26.20 for a 35% zinc product, market at 7 cents; variation above 35% and down to 25% zinc at $1.00 per unit up or down; market variation for 75% of metal content when spelter is selling at less than 7 cents down to a fixed limit, and market variation when spelter is selling above 7 cents.

21. Operative 1916, base price $19.00 for a 35% zinc product, with a variation above 35% and down to 25% at $1.00 per unit.

22. Operative 1916, base price $17.00 for a 40% zinc product when market is at 5 cents; variation $1.50 per unit when spelter is above 10 cents, and $1.00 per unit when below 10 cents; market variation between 5 and 7 cents add $4.00 per ton, between 7 and 14 cents add $3.00 per ton, for each cent in advance in each case.

23. Operative 1916, base price $23.50 for a 40% zinc product when market is at 6 cents; variation $1.00 per unit to be added or deducted when spelter is at 12 cents or below, and $1.50 to be added when above 12 cents; market variation under 6 cents pay for 70% of content, when between 6

and 8 cents add 50% of increase for each cent, 8 to 10 cents add 40%, above 10 cents add 30%.

24. Operative 1916, base price $26.00 for a 50% zinc product when market is at 5 cents; variation $1.00 per unit to be added or deducted for each unit above or below 50% metal content; market variation $5.00 per ton for each cent increase in price of spelter.

FREIGHT RATES IN CANADA.

One of the principal factors on which depends the feasibility of producing spelter in Canada is the cost of assembling the various raw materials at the point at which the spelter is to be produced. An attempt has been made to tabulate the various freight rates that would have to be paid on the principal items required by a smelter. The rates given in the following schedules are in some cases new rates that would be given by the railways if the occasion arose. At the present time there is no traffic in the commodities mentioned between some of the points indicated, and the rates are not yet authorized rates.

Zinc Ore Rates.[1]

Point of Origin.	Destination.	Valuation[2] Per ton of 2,000 pounds. Under $10 00	$10.00 to $25.00 inclusive.	Over $25.00 to $50.00 inclusive.	Over $50 00 to $100.00 inclusive.	Over $100.
Ainsworth	Frank	1.40	2.00	3.00	3.60	4.20
Zincton	"	1.50	2.20	3.20	3.80	4.60
Rambler	"	1.50	2.20	3.20	3.80	4.60
Sandon	"	1.50	2.20	3.20	4.00	4.60
Ainsworth	Bow Island	1.80	2.60	3.50	4.60	5.40
Zincton	"	1.95	2.80	3.70	5.00	5.80
Rambler	"	1.95	2.80	3.70	5.00	5.80
Sandon	"	1.95	2.80	3.70	5.00	5.80
Ainsworth	Medicine Hat	1.95	2.80	3.70	5.00	5.80
Zincton	"	2.10	3.00	3.90	5.00	6.00
Rambler	"	2.10	3.00	3.90	5.20	6.00
Sandon	"	2.10	3.00	3.90	5.20	6.00
Nelson	Frank	1.40	2.00	3.00	3.60	4.20
Nelson	Bow Island	1.80	2.60	3.50	4.60	5.40
Nelson	Medicine Hat	1.95	2.80	3.70	5.00	5.80
Nelson[3]	Trail	....	....	.60	....	....
Salmo	Frank	....	....	4.25	5.60	7.20
Salmo	Bow Island	....	....	4.75	6.60	8.40
Salmo	Medicine Hat	....	....	4.95	7.00	8.80
Kimberley	Trail	....	....	1.85	....	....
Bayview, Idaho	Frank	....	3.25	4.50	....	....
Osborne, Idaho	Frank	....	....	....	6.50[4]	....
Zincton[5]	Roseberry	0.40[6]	....	....	....	....
Three Forks[5]	Roseberry	0.50	....	....	....	....
Sandon[5]	Roseberry	0.50	....	....	....	....
Butte, Mont.	Oklahoma points.	....	....	7.10	7.10	....
Wallace, Idaho	"	....	....	9.85	9.85	....
Wallace, Idaho.	Bayview	....	....	....	4.00	....
Coeur d'Alene	Bayview	....	....	1.25	1.50	....
Bayview	Nelson and Trail	....	....	2.00	3.00	....
Osborne, Idaho	Kingsgate, B.C.	....	....	....	3.50	....
Kingsgate, B.C.	Nelson and Trail	....	....	2.00	3.00	....

Coal rates (car loads).

Bankhead to Medicine Hat .... $2.00 per ton of 2,000 lbs.
Bankhead to Bow Island .... $2.10 " "
Bankhead to Fernie[7] .... $2.20 " "

[1] These rates are maximum rates and must not be exceeded in the same direction from intermediate points on the direct line of transit. The minimum carload weight will be the carrying capacity of the car, except when car is loaded to marked or visible carrying capacity, when actual weight, but not less than 40,000 lbs. will govern.

[2] The valuation is based on the gross value of the ore at point of shipment. The smelter return to the mine owner, before deducting the transportation charges, is the value to be used in determining the freight charges under the provisions of existing tariffs.

[3] Proportionate rate; applies only on shipments ex G. N. Ry.

[4] Rate for $60.00 ore.

[5] When valuation per ton of 2,000 pounds does not exceed $5.00

[6] Plus $2.00 per car switching at Lucky Jim Mines.

[7] Not an authorized rate.

Clay rates (car loads).

St. Louis, Mo., to Missouri Transfer	8·5	cents per	cwt.
St. Louis, Mo., to Bow Island[1]	37·5	„	„
St. Louis, Mo., to Frank	39·5	„	„
St. Louis, Mo., to Fernie[1]	42·5	„	„[2]
St. Louis, Mo., to Macleod[1]	37·5	„	„[3]
Willows, Sask., to Bow Island	13·	„	„
Willows, Sask., to Frank	15·5	„	„
Willows, Sask., to Fernie	16·5	„	„
St. Louis, Mo., to Pueblo, Col	25·0	„	„

Spelter rates.[4]

Trail[5] to	Sault Ste. Marie	75	cents	per cwt.	formerly	60c)
„	Toronto	75	„	„	„	60
„	Hamilton	75	„	„	„	60
„	Montreal	75	„	„	„	60
„	West St. John	87	„	„	„	72
„	Halifax	87	„	„	„	72
„	Vancouver	30	„	„		
„	Frank[6]	38	„	„		
„	Bow Island[6]	40	„	„		
„	Medicine Hat[6]	40	„	„		
Fernie to	Vancouver	84	„	„		
„	Seattle	89	„	„		
„	New York	1·38	„	„		
Anaconda to	New York	50	„	„		

PRODUCTION OF ZINC IN CANADA.[7]

The production of zinc ore in Canada in 1915, as obtained by direct returns from producers, was 14,895 tons, valued at $554,938, as against 10,893 tons, valued at $262,563 in 1914. The zinc content of these shipments was returned as 12,231,439 pounds, which, if valued at the average New York price of spelter during the year—13·230 cents, would be worth $1,618,219, as against 9,101,460 pounds, valued at 5·213 cents per pound, or with a total value of $474,459 in 1914.

The greater part of this production is from British Columbia and the ore shipped contains also a varying silver content, for which payment is made by the smelters, and without which, on account of the import duty to the United States and the long rail haul, it would not in many cases pay to ship. The Slocan mining division produced about one-third of the total output—Nelson about one-fifth, and the balance came principally from the Ainsworth and Fort Steele divisions.

In Quebec, the property at Notre Dame des Anges, Portneuf county, which is being operated by the Weedon Mining Company, shipped several hundred tons of ore.

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[1] Not an authorized rate.

[2] Present advertised rate is 55·5 cents per cwt. minimum car load 50,000 lbs.

[3] Present advertised rate is 50·5 cents per cwt. minimum car load 50,000 lbs.

[4] Subject to loading to 60,000 lbs. per car.

[5] The rates from Trail are blanket rates, and would apply to shipments of spelter from Nelson, Fernie, Frank, or Medicine Hat, unless differential rates based on the haulage distance to the markets indicated, were established.

[6] These rates are not authorized, but are based on the rate from Trail to Vancouver. It will be noted that Trail is favoured by a blanket rate to the eastern market, and a proposed differential rate to the Pacific Coast.

[7] By Arthur Buisson, Assistant Engineer, Division of Mineral Resources and Statistics. Reprinted from the Annual Report of this Divison for 1915.

Statistics of the production of zinc since 1898 are given in the following table:—

Annual Production of Zinc.

Calendar Year.	Zinc ore shipped.		Metallic zinc in ore shipped.	
	Tons.	Spot value.	Pounds.	Final value.
1898	1,162	$11,000	788,000	$36,011
1899	865	18,165	814,000	46,805
1900	261	4,810	212,000	9,342
1901	......	......	......	......
1902	158	1,659	142,200	6,882
1903	1,000	10,500	900,000	48,660
1904	597	3,700	477,568	[illegible],256
1905	9,413	139,200	*	*
1906	1,154	23,800	*	*
1907	1,573	49,100	*	*
1908	452	3,2[illegible]	*	*
1909 (*a*)	18,371	242,[illegible]9	16,468,204	906,245
1910	5,063	120,003	4,361,712	240,766
1911	2,590	101,072	2,346,849	135,132
1912	6,415	215,149	5,354,700	371,777
1913	7,889	186,827	7,069,800	399,302
1914	10,893	262,563	9,101,460	474,459
1915	14,895	554,938	12,231,439	1,618,219

* Figures not available.
(*a*) Includes 7,424 tons shipped late in 1908.

During 1913 the new United States customs tariff came into effect considerably reducing the duties payable on Canadian ores, the new items affecting Canadian shipments being:—

Zinc ores containing 25 per cent or more zinc: 10 per cent on zinc contained therein.

Lead bearing ore: ¾ cent per pound on lead contained therein.

Although not paid for by the United States smelters, the lead in ore is considered as dutiable and as there is often a small lead content i[illegible] [illegible]e zinc ore or concentrates shipped, the lead duty applies. The result [illegible] [illegible]he decreased duties has been a considerable increase in zinc shipments.

There is also a duty of 15 per cent on metallic zinc imported to the United States, and at present an import duty of 7½ per cent on zinc and other materials imported into Canada from the United States.

The price of spelter in New York varied between a minimum of 5¾ cents per pound in January to a maximum of 25 to 27 cents in June, the price at the close of the year being from 15¼ to 16¾ cents and the average for the year 13·230 cents per pound.

The price of high-grade spelter rose from 10 cents at the beginning of the year to over 40 cents i[illegible] [illegible]id-summer and was maintained fairly strongly through the balance of the year at from 35 to 40 cents.

Average Price of Spelter at New York.*

(In cents per pound.)

Month	1905.	1906.	1907	1908.	1909	1910	1911.	1912.	1913.	1914.	1915
January	6·190	6·487	6·732	4·513	5·141	6·101	5·452	6·442	6·931	5·262	6·386
February	6·139	6·075	6·814	4·785	4·889	5·569	5·518	6·499	6·239	5·377	8·436
March	6·067	6·209	6·837	4·665	4·757	5·637	5·563	6·626	6·078	5·250	8·541
April	5·817	6·087	6·687	4·645	4·965	5·449	5·399	6·633	5·641	5·113	10·012
May	5·434	5·997	6·441	4·608	5·124	5·191	5·348	6·679	5·406	5·074	14·781
June	5·190	6·096	6·419	4·543	5·402	5·128	5·520	6·877	5·124	5·000	21·208
July	5·396	6·006	6·072	4·485	5·402	5·152	5·695	7·116	5·278	4·920	19·026
August	5·706	6·027	5·701	4·702	5·729	5·279	5·953	7·028	5·658	5·568	12·781
September	5·887	6·216	5·236	4·769	5·796	5·514	5·869	7·454	5·694	5·380	13·440
October	6·087	6·222	5·430	4·801	6·199	5·628	6·102	7·426	5·340	4·909	12·800
November	6·145	6·375	4·925	5·059	6·381	5·976	6·380	7·371	5·229	5·112	15·962
December	6·522	6·593	4·254	5·137	6·249	5·624	6·301	7·162	5·154	5·592	15·391
Year	5·322	6·198	5·962	4·726	5·503	5·520	5·758	6·943	5·648	5·213	13·230

* From the Engineering and Mining Journal, N.Y.

Average Prices of Spelter, Ordinary Brands, in London.†

(In £ sterling per long ton).

Month.	1906.			1907.			1908.			1909.			1910		
January	28	8	2	27	7	1	20	6	3	21	6	3	23	4	3
February	26	2	4	26	1	5	21	0	7	21	8	9	23	3	1
March	24	15	3	26	4	8	21	1	5	21	8	8	23	3	7
April	25	19	3	25	17	5	21	6	1	21	10	1	22	9	11
May	27	0	2	25	14	2	20	2	10	21	19	1	22	1	1
June	27	9	9	24	10	2	19	2	2	21	19	11	22	3	2
July	26	15	11	23	18	11	18	14	1	21	18	9	22	5	6
August	27	0	5	22	1	7	19	6	9	22	0	3	22	14	0
September	27	12	5	21	0	11	19	10	3	22	17	1	23	2	7
October	27	18	10	21	12	11	19	15	1	23	3	4	23	16	6
November	27	15	1	21	8	4	20	17	1	23	2	1	24	1	9
December	27	19	3	20	3	3	20	19	2	23	1	3	23	17	7
Year	27	1	5	23	16	9	20	3	6	22	2	11	23	0	0

Month.	1911.			1912.			1913.			1914.			1915.		
January	23	16	7	26	9	11	25	19	1	21	6	6	30	16	1
February	23	3	10	26	6	5	25	4	3	21	7	6	39	16	4
March	22	19	2	25	19	11	24	11	4	21	7	7	44	2	7
April	23	13	0	25	8	11	25	2	4	21	10	2	49	17	9
May	24	6	1	25	11	2	24	10	4	21	5	9	67	19	0
June	24	9	7	25	11	11	21	19	10	21	6	0	100	12	3
July	24	13	10	25	13	1	20	11	2	21	6	7	97	5	0
August	26	11	2	26	1	2	20	14	0	29	0	9	67	15	9
September	27	12	7	26	17	0	21	3	10	25	14	0	67	17	9
October	27	4	10	27	5	10	20	13	9	23	13	6	66	10	11
November	26	13	2	26	14	3	20	14	4	24	14	10	85	6	4
December	26	13	7	26	0	4	21	6	8	27	6	10	82	4	1
Year	25	3	2	26	3	3	22	14	3	23	6	8	66	13	8

† From the annual publication of the "Metal Information Bureau," London, E.C.

The imports of zinc, which may be taken as an index of consumption, show a fairly steady increase and amounted in 1915 to 15,919,500 pounds of zinc in blocks or pigs, spelter and tubing, valued at $2,010,602; 12,251,257 pounds of zinc white, zinc dust, zinc sulphate and chloride of zinc, valued at $743,045; and manufactures of zinc, valued at $21,711.

The total value of the imports of brass in 1915, which alloy contains about 30 per cent zinc, was $[illegible],177,942 and was made up as follows: brass in blocks, pigs or ingots 1,[illegible] pounds, valued at $226,499; "old and scrap," tubing and plain wire, 2,133,148 pounds, valued at $487,911; brass in bars and rods and strips, sheets or plates, valued at $450,372; brass caps for electric batteries, caps for shells, wire cloth, nails and tacks and handpumps, valued at $[illegible]4; and other manufactures of brass, valued at $1,406,676.

The imports of zinc [illegible] 1914 were valued at $1,174,297 and included 14,006,300 pounds of zinc [illegible], pigs, spelter and tubing, valued at $740,816; 10,160,221 pounds [illegible] white, zinc dust, zinc sulphate and chloride of zinc, valued at $4[illegible]; and manufactures of zinc, valued at $36,355.

The imports of brass [illegible] valued at $2,858,088 and included, brass in blocks, [illegible] pounds, valued at $126,357, "old and scrap," tubing and [illegible] 880 pounds, valued at $525,005; brass in bars and rods (free), 1,74[illegible] pounds valued at $285,656; brass in bars and rods and strips, sheets [illegible], valued at $205,560; brass caps for electric batteries, caps for shells, wire cloth, nails and tacks, and handpumps, valued at $269.612; and other manufactures of brass, valued at $1,445,898.

The estimated zinc contents of zinc products and of brass imported during the past two years is shown in the following table according to which the consumption of zinc during 1915 amounted to at least 13,389 tons together with the zinc contents of manufactures of zinc and of brass which would probably not exceed 1,000 tons.

The zinc imports during 1912 amounted to over 16,000 tons of metal and according to the Customs records, exceed the imports during 1914 and 1915.

Summary of Imports of Zinc and Zinc Products in 1914 and 1915.

Zinc and Zinc Products.	1914.			1915		
	Product in pounds.	Value of product	Zinc content in pounds.	Product in pounds.	Value of product.	Zinc content in pounds
Zinc, in blocks, pigs and sheets	3,160,900	$189,785	3,160,900	1,653,700	$226,104	1,653,700
Zinc, as spelter	10,845,400	551,031	10,845,400	14,265,700	1,784,471	14,265,700
Zinc, seamless tubing	..			100	27	100
Zinc white	9,445,397	389,796	(80%) 7,556,318	11,368,569	656,132	(80%) 9,094,855
Zinc dust	362,109	34,295	(90%) 325,898	503,143	70,823	(90%) 452,829
Zinc sulphate and chloride of	352,715	9,390	(44%) 155,195	379,545	16,090	(44%) 167,000
Total	24,166,521	$1,174,297	22,043,711 (11021·8 tons)	28,170,757	$2,775,331	25,634,184 (12817 1 tons)
Zinc, as manufactures of	....	$36,355	....	....	$21,711	
Brass in blocks, pigs, and ingots	1,010,600	$126,357	(30%) 303,180	1,677,800	$226,499	(30%) 503,340
Brass, old and scrap	1,407,900	150,346	" 422,370	311,900	41,971	93,570
Brass tubing	1,590,573	314,675	" 477,172	1,381,482	349,988	414,445
Brass, plain wire	370,407	59,984	" 111,122	439,766	95,952	131,930
Brass bars and rods (free)	1,747,700	285,656	" 524,310			
Total	6,127,180	$937,018	1,838,154 (919·1 tons)	3,810,948	$714,410	1,143,285 (571 6 tons)
Brass bars and rods	....	$ 94,827	....	....	$215,782	
Brass strips, sheets or plates	....	110,733	....	....	234,590	
Brass wire cloth, n.o.p.	....	120,614	....	....	147,464	
Brass cups for manuf. of shells	....	124,622	....	....	435,161	
Brass caps for electric batteries	....	5,684	....	....	5,367	
Brass nails, tacks, etc	....	6,736	....	....	7,562	
Brass handpumps	....	11,956	....	....	10,930	
Brass, other manufactures, n.o.p.	....	1,445,898	....	....	1,406,676	
Total	....	$1,921,070	....	....	$2,463,532	

Imports of Zinc.

Fiscal year.	In blocks, pigs and sheets.		As spelter.		As manufactures of zinc.	Seamless tubing.	
	Cwt.	Value.	Cwt.	Value.	Value.	Pounds.	Value.
1880	13,805	$67,881	1,073	$ 5,301	8,327	...	...
1881	20,920	94,015	2,904	12,276	20,178	...	...
1882	15,021	76,631	1,654	7,779	15,526	...	...
1883	22,765	94,799	1,274	5,196	22,599	...	...
1884	18,945	77,373	2,239	10,417	11,952	...	...
1885	20,954	70,598	3,325	10,875	9,459	...	...
1886	23,146	85,599	5,432	18,238	7,345	...	...
1887	26,142	98,557	6,908	25,007	6,561	...	...
1888	16,407	65,827	7,772	29,762	7,402	...	...
1889	19,782	83,935	8,750	37,403	7,233	...	...
1890	18,236	92,530	14,570	71,122	6,472	...	...
1891	17,984	105,023	6,249	31,459	7,178	...	...
1892	21,881	127,302	13,909	62,550	7,563	...	...
1893	26,446	124,360	10,721	49,822	7,464	...	...
1894	20,774	90,680	8,423	35,615	6,193	...	...
1895	15,061	63,373	9,249	30,245	5,581	...	...
1896	20,223	80,784	10,897	40,548	6,290	...	...
1897	11,946	57,754	8,342	32,826	5,145	...	...
1898	35,148	112,785	2,794	13,561	10,503	...	...
1899	18,785	107,477	5,450	29,687	[illegible],661	...	...
1900	28,748	156,167	5,836	29,416	[illegible]75	...	...
1901	20,527	103,457	14,621	58,283	6,882	...	...
1902	34,871	141,560	18,356	80,757	6,683	...	...
1903	26,646	142,827	23,159	110,817	9,754	...	...
1904	25,553	138,057	33,952	164,751	12,682	...	...
1905	25,141	141,514	37,941	206,244	11,912	...	...
1906	24,462	158,438	50,137	290,686	12,917	...	...
Calendar year.							
1907	30,130	198,570	58,430	348,810	21,812	670	$53
1908	24,273	130,689	54,870	254,225	14,577	...	...
1909	35,283	199,016	120,615	592,148	16,073	...	...
1910	31,660	191,051	109,084	561,170	21,829	...	...
1911	33,678	206,859	116,996	654,097	30,862		
1912	100,095	617,836	117,845	686,585	46,336	...	...
1913	47,226	291,368	126,051	661,207	54,898	...	...
1914	31,609	189,785	108,454	551,031	36,355	...	...
1915	16,537	226,104	142,657	1,784,471	21,711	100	27

Imports of Zinc White, Zinc Dust, and Zinc Sulphate and Chloride.

Calendar Year.	Zinc white.		Zinc dust.		Zinc sulphate and chloride.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1910	8,496,399	$312,779	97,461	$ 4,859	237,466	$ 6,470
1911	8,537,498	314,194	86,242	5,718	414,500	15,930
1912	10,505,944	425,714	308,239	18,944	941,780	29,104
1913	12,682,126	525,643	412,294	26,403	634,634	17,424
1914	9,445,397	389,796	362,109	34,295	352,715	9,390
1915	11,368,569	656,132	503,143	70,823	379,545	16,090

British Columbia:—The annual production of zinc in British Columbia, by districts, showing zinc contents of ores shipped during the past five years, as recorded by the Provincial Bureau of Mines, is presented in the next table.

According to the Provincial Mineralogist:—

The total quantity of zinc produced in 1915 was 12,982,440 pounds of which 8,684,572 pounds came from the Slocan District; 3,127,209 pounds from Nelson Division; 678,940 pounds from Ainsworth Division, and 491,719 pounds from East Kootenay.

The largest producer in the Province was the Standard, in Slocan Division, which is credited with 3,778,857 pounds, followed by the H. B., in Nelson Division, with 2,387,514 pounds, and the Silverton Mines, Slocan, with 1,385,859 pounds; while the Zincton mine, in Nelson District, produced 739,695 pounds; the J. L. Retallack Mines, in Ainsworth 576,000 pounds; the Lucky Jim, in Slocan, 788,158 pounds; and the Rambler-Caribou 540,660 pounds.

It is also pointed out that the supply of ore brought out by the extraordinary high prices quoted for spelter "was so great that such smelters as were equipped to handle it only bought at a very large margin of profit so that the zinc miner did not make as great profits as the increased market price of the metal would seem to indicate."

British Columbia—Production of Zinc by Districts.*

(Contents of ore shipped, in pounds).

	1911.	1912.	1913.	1914.	1915.
East Kootenay—					
Fort Steele	....	....	....	....	180,000
Other districts	....	142,643	....	....	311,719
West Kootenay—					
Ainsworth	....	....	150,680	280,000	678,940
Nelson	....	....	....	332,003	3,127,209
Slocan	2,634,544	5,215,637	6,608,088	7,254,464	8,684,572
Total	2,634,544	5,358,280	6,758,768	7,866,467	12,982,440

* From the Report of the Minister of Mines, B.C.

World's Production of Spelter.*

In Short Tons.

Country.	1908.	1909.	1910.	1911.	1912.	1913.
Australia	1,198	....	560	1,904	2,531	4,105
Austria and Italy	14,063	13,931	14,666	18,602	21,609	213,928
Belgium	181,851	184,194	190,233	215,050	220,678	217,928
France and Spain	61,512	61,859	65,191	70,791	79,543	78,289
Germany	239,062	242,594	251,046	276,008	298,794	312,075
Great Britain	60,029	65,422	69,531	73,803	63,086	65,197
Holland	19,017	21,548	23,121	25,059	26,380	26,811
Poland	9,740	8,758	9,514	10,952	9,659	8,389
United States	210,424	255,760	269,184	286,526	338,806	346,676
Norway	....	....	....	7,363	8,959	10,237
Total	796,896	854,066	893,046	986,058	1,070,045	1,093,635

* Mineral Resources of the United States.

World's Consumption of Spelter*

In Short Tons.

Country.	1908.	1909.	1910.	1911.	1912.	1913.
Austria-Hungary	35,935	36,155	37,258	47,950	51,588	44,533
Belgium	74,956	71,209	84,326	81,240	85,098	84,216
France	85,869	73,744	62,059	90,389	90,389	89,286
Germany	198,634	207,343	203,374	241,734	248,899	255,734
Great Britain	152,669	171,408	195,989	193,674	204,146	214,508
Holland	4,189	4,409	4,409	4,409	4,409	4,409
Italy	9,259	9,039	8,929	11,133	11,795	12,015
Russia	19,621	20,282	27,447	31,856	30,754	36,707
Spain	5,512	4,960	4,630	5,291	5,181	6,503
United States	214,167	270,730	245,884	280,059	340,372	295,370
Other countries	11,023	9,921	13,669	19,621	21,715	23,038
Total	811,834	879,200	887,974	1,007,356	1,094,346	1,066,319

* Mineral Resources of the United States.

There are now in Canada three companies constructing, or operating, electrolytic plants, viz: The Electro Zinc Company at Welland, which uses the Watts process; the French Complex Ore Reduction Company at Nelson, using the French process; and the Consolidated Mining and Smelting Company of Canada, Limited, at Trail, which Company has erected a large plant and is increasing its capacity so as to treat, it is reported, about 60 tons per day.

In December of 1915 these operations with the possible exception of Trail, were still in the experimental stages of development. The Welland plant was designated to recover refined zinc from zinc oxide although it was ultimately intended to extend the operations to include the reduction of zinc ores from Notre Dame des Anges, in Quebec.

The French Complex Ore Reduction Company conducted a further demonstration of the "French" process at the Standard Silver Lead Mining Company's mill at Silverton. Satisfactory results were claimed although operations were discontinued.

The "Daily Colonist" of Victoria, on Sept. 12, 1915, reported:—

That the Provincial Government had decided to extend a measure of financial assistance to the French Complex Ore Reduction Company, so that a demonstration plant of some practical usefulness may be established at Nelson; also to lease to the Company, on favourable terms the old Government plant.

The Government was extending a measure of aid to the Company in view of the possibility of encouraging the greater production of zinc in British Columbia, a matter of vital concern to the Imperial Government, in view of the use of zinc in the manufacture of munitions of war.

During 1916 a government bill was introduced in the Provincial Legislature, to guarantee bonds of the French Complex Ore Reduction Company to the amount of $40,000.

At Trail,—

Considerable experimental work was carried on during the year in the production of electrolytic zinc, and spelter of a good grade has been produced at the rate of about one half ton per day from zinc contained in the Sullivan ore. The results have been promising enough to warrant the building of a larger plant, and, on account of exceptional circum-

stances, a plant of twenty-five to thirty-five tons capacity of spelter per day has been designed and is now being erected. It is hoped that this will be in operation early in the year. The operation of this plant should make available a very large amount of complex ore at the Sullivan mine, and the extraction of this ore will probably lead to the development of further bodies of lead ore in the same mine.

The Trail plant started regular commercial operations early in 1916 and in July was reported to be producing 20 tons per day.

In August, 1915, the Dominion Government announced, as follows, its intention to provide a measure of assistance toward stimulating the establishment of a zinc smelting industry in Canada.

A committee of the Government under the chairmanship of the Minister of Finance, after full discussion with members of the Shell Committee, has satisfactorily solved the problem of ensuring at reasonable prices a Canadian supply of zinc suitable for use in the production of brass for the making of quick-firing cartridge cases for shells. Before the outbreak of war this quality of zinc sold at about eight cents per pound. Since that time the price has steadily risen as high as forty cents and grave fears were entertained that the supply might be entirely cut off. At present the sources of supply are outside of Canada. The Shell Committee, representing the British Government in the purchase of shells in Canada, regarded it as absolutely necessary that there should be supplies of this zinc within Canada. Canadian producers were unwilling to go to the large expense of installing refineries unless insured against the fall in zinc prices, which is inevitable after the close of the war. After considerable negotiation the Government decided to offer a limited bounty for the production in Canada of zinc.

An Act to provide for the payment of bounties on zinc produced from zinc ores mined in Canada was passed by the House of Commons of Canada, May 3rd, 1916, and reads as follows:—

"An Act to provide for the payment of Bounties on Zinc produced from Zinc Ores mined in Canada."

"His Majesty, by and with the advice and consent of the Senate and House of Commons of Canada, enacts as follows:

"1. This Act may be cited as The Zinc Bounties Act, 1916.

"2. Whenever it appears to the satisfaction of the Minister of Trade and Commerce who is charged with the administration of this Act, that the standard price of zinc or spelter in cakes, blocks or pigs, in London, England, is less than £36 19s. 3d. sterling, per ton of two thousand two hundred and forty pounds, the Governor in Council may authorize the payment out of the Consolidated Revenue Fund of a bounty on zinc or spelter, containing not more than two per centum of impurities, produced in Canada, at the time the price is as hereinbefore stated, from zinc ores mined in Canada. Such bounty shall be equal to the difference between such standard price per ton and £36 19s. 3d. per ton, but shall in no case exceed two cents per pound, and in no event shall any bounty be paid when the price received for such zinc and spelter by the producer is eight cents or more per pound."

"3. No bounty shall be payable under this Act on zinc or spelter produced during the continuation of the war, and in no event shall bounty be payable on zinc or spelter produced after the thirty-first day of July, one thousand nine hundred and seventeen."

"4. The total amount payable under the provisions of this Act shall not exceed the sum of $400,000."

"5. The Governor in Council may make regulations for carrying out the provisions of this Act."

Electrolytic Zinc Plants in Canada.

Company.	Location of plant.	Remarks.
Consolidated Mining and Smelting Company of Canada, Ltd.	Trail, B.C.	Capacity of plant, 50 tons of refined zinc per day being increased to 100 tons per day.
Electro Zinc Company, Ltd.	Welland, Ont.	Experimental in 1915. Small plant for recovery of zinc from zinc oxide.
French Complex Ore Reduction Company	Nelson, B.C.	Experimental. Small demonstrations at Nelson, B.C.

Electrolytic Zinc Plants in the United States.*

Company.	Location of plant.	Daily spelter capacity.	Remarks.
American Smelting and Refining Co.	Omaha, Nebr.	Experimental	Operated in 1915.
Do. Do.	Garfield, Utah	10 tons	Planned.
Anaconda Copper Mg. Co.	Anaconda, Mon.	25 tons	Under construction; 10 tons operated in 1915.
Do. Do.	Great Falls, Mont.	100 tons	Under construction.
Bully Hill Copper Co.	Bully Hill, Cal.	Experimental	Operated in 1915.
Daly-Judge Mining Co.	Park City, Utah	10 tons	Under construction.
Electrolytic Zinc Co.	Baltimore, Md.	15 tons	Do. Do.
Mammoth Copper Mg. Co.	Kennett, Cal.	10 tons	Under construction: 2½ tons now in operation.
Northwestern Metals Co.	Helena, Mont.	Experimental	Operated in 1915.
		Ore capacity 100 tons	Malm process; not operated in 1915.
Reed Zinc Co.	Palo Alto, Cal.	Experimental	Operated in 1914-15.
River Smelting and Refining Co.	Keokuk, Iowa	Experimental	Operated in 1915.
Western Metals Co.	Georgetown, Colo.	Ore capacity 100 tons	Malm process; under construction.

* As published by the United States Geological Survey.

Active Zinc Smelters in the United States, and Capacity in 1916, by Companies and States.*

Company.	Location.	Acid plants.	Retorts at close of 1915.	Retorts June 30, 1916.	Additional retorts contemplated or under construction.
Fort Smith Spelter Co.	Fort Smith, Ark.			2,560	
Arkansas Zinc Co.	Van Buren, „			2,400	
United States Zinc Co.	Pueblo, Colo.		2,208	1,944	
American Zinc Co. of Illinois	Hillsboro, Ill.	A	4,000	4,864	
Collinsville Zinc Sm.	Collinsville, Ill.		1,792	2,304	
Granby Mg. and Sm. Co.	E. St. Louis, „	A	3,220	3,220	2,400
Hegeler Zinc Co.	Danville, „	A	3,600	5,400	
Illinois Zinc Co.	Peru, „	A	4,640	4,640	800
Matthiesson & Hegeler Zinc Co.	La Salle, „	A	6,168	6,168	
Missouri Zinc Co.	Beckemeyer, „		352	352	
Mineral Pt. Zinc Co.	Depue, „	A	9,068	9,068	
National Zinc Co.	Springfield, „	A	3,200	4,480	
Robt. Lanyon Z. and Acid Co.	Hillsboro, „	A	1,840	3,200	
Sandoval Zinc Co.	Sandoval, „		672	672	
American Spelter Co.	Pittsburgh, Kan.		896	992	
American Zinc, Lead and Smelting Co.	Caney, „		6,080	6,080	
Do. Do.	Dearing, „		4,480	4,480	
Chanute Spelter Co.	Chanute, „		1,280	1,280	
Cherokee Smelting Co.	Bruce, „		896	896	
Edgar Zinc Co.	Cherryvale, „		4,800	4,800	
Granby Mg. & Sm. Co.	Neodesha, „		3,760	3,760	
Iola Zinc Co.	Concreto, „		660	1,320	
Joplin Ore and Spelter Corporation	Pittsburgh, „		1,444	1,792	
Lanyon Smelting Co.	Pittsburgh, „		448	448	
Owen Zinc Co.	Caney, „		1,280	1,280	640
Pittsburg Zinc Co.	Pittsburgh, „		910	910	
Prime Western Spelter Company	Gas, „	A	4,868	4,868	
U. S. Smelting Co.	Altoona, „		3,960	4,600	
Do. Do.	Iola, „		3,440	3,440	
Do. Do.	La Harpe, „		1,924	1,924	
Weir Smelting Co.	Weir, „				448
Edgar Zinc Co.	St. Louis, Miss.		2,000	2,000	
Miss. Zinc Sm. Co.	Rich Hill, „			448	
Nevada Smelting Co.	Nevada, „		672	572	
Bartlesville Zinc Co.	Bartlesville, Okla.		5,184	6,336	
Do. Do.	Blackwell, „			1,600	4,800
Do. Do.	Collinsville, „		10,752	13,440	
B[illegible]sville Zinc Co. (Lanyon-Starr Plant)	Bartlesville, „		3,456	3,456	
Eagle-Picher Lead Co.	Henryetta, „				4,000
Henryetta Spelter Co.	Henryetta, „			3,000	
J. B. Kirk Gas and Sm. Co.	Checotah, „			2,560	2,560
Kusa Spelter Co.	Kusa, „		3,720	3,720	
La Harpe Spelter Co.	Kusa, „			4,000	
National Zinc Co.	Bartlesville, „		4,970	4,970	
Oklahoma Spelter Co.	Kusa, „			1,600	
Quinton Spelter Co.	Quinton, „				1,340
Tulsa Fuel & Mfg. Co.	Collinsville, „		6,232	6,232	
U. S. Zinc Co.	Sand Springs, „		5,680	8,000	
American Steel & Wire Co.	Donora, Penn.	A	3,648	9,120	
American Zinc & Chemical Co.	Langeloth, „	A	3,648	6,384	912
N. J. Zinc Co. (of Pa.)	Palmerton, „		6,720	6,960	
Clarksburg Zinc Co.	Clarksburg, W. Va.		3,648	3,648	
Grasselli Chemical Co.	Clarksburg, „	A	5,760	5,760	
Do. Do.	Meadowbrook „	A	8,592	8,592	
United Zinc Smelting Corporation	Moundsville „	A			6,912
Total for all States			156,568	196,640	24,812
	Plants with special retorts:				
	Michael Hayman & Co., Buffalo, N.Y.		12	12	
	Trenton Sm. & Refining Co., Trenton, N.J.		96	60	
	Wm. Cramp & Sons Ship and Engine Bldg. Co., Philadelphia, Pa.		32	32	

SUMMARY AND CONCLUSIONS.

The following conclusions represent the author's personal opinions. These opinions are based not only on the data obtained during this present investigation, but also on observations made during a previous investigation of the same subject in 1912. The author has also been in close touch with conditions in the non-ferrous metal industries in Canada during the period of the European war, and has had knowledge of the requirements for munition work.

1. The author considers that, so far as the actual operations of a smelter are concerned, the cost of smelting in the Crowsnest Pass area or on the Pacific coast would not be much greater than in the middle Western States where coal is used for fuel, and with cooperation between all the interests concerned, it could be carried on here as cheaply or cheaper than elsewhere. The cost in the natural gas areas in Canada would be greater than in corresponding areas in the United States, but not at all prohibitive. The author considers that it is not in the public interest to permit natural gas to be used for zinc smelting. The difficulties of obtaining skilled labour and trained supervision are not insuperable, most of the raw materials apart from ores, could probably be obtained locally. If suitable ores were available for treatment, spelter could be produced at a cost which would compare favourably with the cost of production by these methods elsewhere.

2. The author is in accord with all previous investigators in concluding that it has not been demonstrated that British Columbia silver-lead-zinc mines are capable of producing enough high grade zinc ore concentrates to support a smelter operating on the Belgian or any similar process. There is not a sufficient tonnage of high grade ores known to be available without importing foreign ores; the silver-zinc concentrates now produced are of too low a grade to be treated commercially in a smelting plant whose only source of supply is these ores; the tonnage produced is too small; the output is too irregular; the methods of concentration now in use, with two exceptions, are inefficient and wasteful; there is a great lack of cooperation among the various producers.

3. An independent zinc smelting plant would be handicapped for lack of a silver refinery. It would have to consign all lead and silver residues to the smelter at Trail, or to Helena, Montana, entailing additional freight charges against the ore and curtailing the possible profits to the smelter. The alternative would be to establish its own refinery, which would necessitate entering a limited market on a competitive basis for lead ores. The operation of silver refineries to treat retort residues only has not proven to be a profitable operation for the zinc smelters. Such a plant would probably be unable to secure any revenue from sulphuric acid, made as a by-product at most United States plants.

4. It would have been commercially feasible to have established a zinc smelter on the Pacific Coast any time during the first half of the year 1915, to treat British Columbia zinc ores, and ores from Australia. The product from such a plant would have found a ready market for certain classes of munition work, but would not have been suitable for making brass for cartridges and shell cases. Owing to the prevailing high prices of zinc this plant would have easily paid for itself during the first year of operation, the production of zinc ores in British Columbia would have been greatly stimulated, a better knowledge of the possibilities of zinc mining in British Columbia would have been obtained, and the returns to producers would have been greater than they have been.

5. As an alternative, it would have been commercially feasible to have established a zinc smelter in the Crowsnest Pass area, or to have rehabilitated the old Frank smelter at any time during the first half of the year 1915, to treat zinc ores from the Kootenays. The supply of ore available would not have been adequate for a large plant, but foreign ores could have been imported. The conditions of the zinc market and the preference that would have been given in the home market, would have made such a venture profitable for a time. The quantity of zinc that could have been produced would have been less than if such a plant had been established on the coast, because the ores available are of a lower grade than the Australian ores, are more difficult to treat and are limited in quantity.

6. There is a notable lack of cooperation among the independent zinc producers. The organization of a Zinc Producers Association to supervise all matters of common interest, and to enable the various producers to cooperate more closely with each other, in matters of mutual concern, would tend to improve conditions in the zinc industry.

7. The majority of the coal producers in the west do not appear at any time to have been willing to make any serious effort to assist in the establishment of a zinc smelting industry. The prices quoted, so far as they have come under my observation, with one exception, are higher than are usually demanded in other fields for products of similar grade. When one considers that there is a considerable quantity of material, now a waste product, that could be utilized by the zinc smelter, it would seem that more encouragement might have been given.

8. The establishment of the new electrolytic plant at Trail, and the proposed establishment of the plant at Nelson by the French Complex Ore Reduction Company have materially altered the situation with respect to a market for British Columbia zinc ores. The process being used at Trail is still undergoing development, and the Consolidated Mining and Smelting Company is not in the market to purchase zinc ores, having an ample supply of their own. As soon, however, as the initial difficulties are overcome it is their intention to purchase ores suitable for treatment in

their plant, and subject to the market demands for spelter. The capacity of the plant will be such that they should be able to treat a large percentage of the zinc output of the Kootenays.

9. The establishment of a zinc smelting plant in British Columbia at the present time does not appear feasible for the following reasons:—

a. Inadequate supply of suitable ores.

b. Inadequate supply of suitable labour.

c. Lack of knowledge of suitability of local clays for retort purposes.

d. High cost of structural materials, including fire brick.

e. The retorting process is not especially adapted to treat the complex silver-lead-zinc ores which comprise the bulk of the British Columbia output, whereas developments now going on in electrolytic processes give promise of a solution of this problem.

f. The electrolytic processes also give promise of a greater adaptability to the peculiar needs of British Columbia ores. If these processes are successful it may prove to be possible to treat some ores locally in plants of smaller unit size than are practicable in smelting by a retort process.